DEMONSTRATION OF THE NATURAL FREEZE-THAW PROCESS FOR THE DESALINATION OF WATER FROM THE DEVILS LAKE CHAIN TO PROVIDE WATER FOR THE CITY OF DEVILS LAKE

by:

John E. Boysen
B.C. Technologies, Inc.
507 Ivinson Street
Laramie, WY 802070

and

Bradley G. Stevens, P.E.
Energy & Environmental Research Center
University of North Dakota
Box 9018
Grand Forks, ND 58202-9018

Grant Agreement No. 98-FG-81-0065

Special Technologies Report No. 71
Desalination Research and Development Program Report No. 71

August 2002

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Reclamation
Technical Service Center
Water Treatment Engineering and Research Group

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 2002	

4. TITLE AND SUBTITLE

Demonstration of the Natural Freeze-Thaw Process for the Desalination of Water from the Devils Lake Chain to Provide Water for the City of Devils Lake

5. FUNDING NUMBERS

Grant Agreement No. 98-FG-81-0065

6. AUTHOR(S)

John E. Boysen and
Bradley G. Stevens, P.E.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

B.C. Technologies, Inc.
507 Ivinson Street
Larimie
WY 802070

Energy & Environmental Research Center
University of North Dakota
Box 9018
Grand Forks, ND 58202-9018

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Bureau of Reclamation
Denver Federal Center
PO Box 25007
Denver CO 80225-0007

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

Special Technologies Report No. 71

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Available from the National Technical Information Service, Operations Division, 5285 Port Royal Road, Springfield, Virginia 22161

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Natural freeze-thaw (FT) desalination of saline surface water is demonstrated in North Dakota for the purpose of providing a new water supply for the City of Devils Lake. The project took saline feed water directly from Devils Lake and desalinated it using the natural FT process. Samples of feed, treated water, and concentrated brine were collected and analyzed during operations to allow sufficent data to be collected to determine the performance and cost of a full-scale FT plant and to validate the demonstration of the process.

Site selection, simulation testing, and design and construction of the FT demonstration plant were performed during the summer and fall of 1998 followed by plant startup and shakedown in late December of that year. The FT plant was operated in the freezing mode for 2 ½ months (from January 1 to March 15, 1999) during which time 4.4 million gallons of Devils Lake water was applied to two freezing pads. Over the next 2 ½ months (through June 2, 1999) the ice was allowed to melt, resulting in the recovery of 3.68 million gallons (84 percent by volume) of treated water with a salinity of 450 ppm total dissolved solids.

14. SUBJECT TERMS –

Water treatment, desalting, Freeze-thaw desalination, concentrated brine, demonstration plant

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UL	UL	UL	UL

Mission Statements

U.S. Department of the Interior

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor out trust responsibilities to tribes.

Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Federal Disclaimer

The information contained in this report regarding commercial products or firms may not be used for advertising or promotional purposes and is not to be construed as an endorsement of any product or firm by the Bureau of Reclamation.

The information contained in this report was developed for the Bureau of Reclamation: No warranty as to the accuracy, usefulness, or completeness is expressed or implied.

ACRONYMS

BCT	B.C. Technologies, Ltd.
BP	brine pond
EC	electrical conductivity
EERC	Energy & Environmental Research Center
EPA	U.S. Enviornmental Protection Agency
FP	freezing pads
FT	freeze-thaw
gpm	gallons per minute
HDPE	high-density polyethylene
ppm	parts per million
NDDH	North Dakota Department of Health
NDPDES	North Dakota Pollution Discharge Elimination System
Reclamation	Bureau of Reclamation
TW	treated water
TDS	total dissolved solids
XNSDWR	National Secondary Drinking Water Regulations
XRD	x-ray diffraction
XRF	x-ray fluorescence

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

Figures

TABLE OF CONTENTS (CONTINUED)

Tables

Appendices

EXECUTIVE SUMMARY

The purpose of this project, conducted by the Energy & Environmental Research Center (EERC) and B.C. Technologies, Ltd. (BCT), was to demonstrate the potential of using the natural freeze–thaw (FT) process for the treatment of saline surface water from the Devils Lake chain to provide a new water supply for beneficial use applications by the city of Devils Lake, North Dakota. This project took saline feedwater for treatment directly from Devils Lake and desalinized the water using the natural FT process. Samples of feed, treated water (TW), and concentrated brine were collected and analyzed during operations to allow sufficient data to be collected to determine the approximate performance and cost of a full-scale FT plant and to validate the demonstration of the FT process.

Successful demonstration of the FT process under North Dakota climatic conditions could facilitate application of the FT process throughout the region. The successful demonstration of the FT process for the desalination of Devils Lake water also provided data for planning a permanent facility in the Devils Lake chain. Furthermore, demonstration of the FT process in this application provided information allowing assessment of the potential of the process to contribute to future disaster mitigation efforts related to the overflow of Devils Lake waters into the surrounding area.

The demonstration project included the following deliverables:

Task 1 – FT Demonstration Site Selection
Task 2 – FT Simulation Testing with Devils Lake Water
Task 3 – FT Demonstration Plant Design
Task 4 – Acquisition of Required Site Permits
Task 5 – FT Demonstration Plant Construction
Task 6 – Demonstration Plant Startup and Shakedown
Task 7 – Operation of the FT Demonstration Plant
Task 8 – Site Reclamation
Task 9 – Plant Performance Assessment, Economic Evaluation, and Integration into Flood Mitigation Plans

Site selection, FT simulation testing, and FT plant design and construction were performed during the summer and fall of 1998. FT plant startup and shakedown were performed from December 28, 1998, through January 1, 1999. From January 1, 1999, through March 15, 1999, the FT plant was operated in a freezing mode, applying and freezing approximately 4,400,000 gallons of Devils Lake water to two freezing pads (FP). From March 15, 1999, through June 2, 1999, the ice piles were allowed to melt, and 3,684,290 gallons of TW were recovered, having an electrical conductivity (EC) of approximately 450 parts per million (ppm), representing a freshwater yield of approximately 84-percent, by volume. In addition, 123,701 gallons of brine having an EC of approximately 11,500 ppm, 253,507 gallons of nondischargable intermediate water, and 182,583 gallons of dischargable intermediate water were recovered. Approximately 7700 pounds of precipitate (primarily calcium carbonate) were formed and left behind on the fp.

On the basis of technical data, the FT demonstration plant operated at Devils Lake was successful at reducing salt concentrations of Devils Lake water to acceptable levels, compared to other raw water sources.

INTRODUCTION

The Devils Lake freeze–thaw (FT) project, conducted by the Energy & Environmental Research Center (EERC), Grand Forks, North Dakota, and B.C. Technologies, Ltd. (BCT), Laramie, Wyoming, was sponsored by three entities: the city of Devils Lake, the North Dakota Department of Health (NDDH), and the Bureau of Reclamation (Reclamation). The project schedule is provided in figure 1.

FREEZE–THAW SIMULATION TESTING WITH DEVILS LAKE WATER

Simulation Testing Procedure

Approximately 30 gallons of water was obtained from Devils Lake, near the city of Devils Lake, North Dakota. A simulation of the FT process was conducted to provide sufficient samples of treated water (TW) and brine for a detailed chemical analysis of the samples (table 1). The simulation was conducted to confirm the ability of the process to meet performance requirements of the appropriate State and Federal regulatory agencies. The experimental results were also used to define the onsite demonstration sampling and process monitoring requirements.

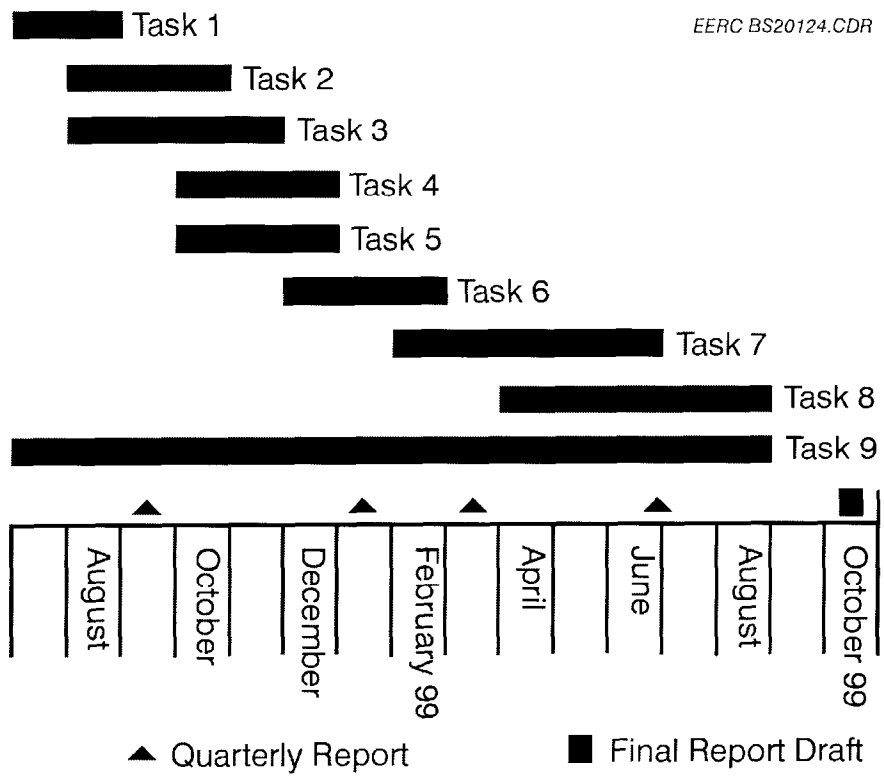


Figure 1.—Project schedule (the project was initiated on June 1, 1998).

Table 1.—Summary of Analytical Results for Simulation Samples

Analyte	Feed	Treated	Intermediate	Brine
Conductivity, µS/cm	2,130	544	2,960	24,900
Dissolved Solids (ppm), total	1,415	313	2,020	24,000
Hardness, total as $CaCO_3$	509	137	564	7,120
Alkalinity ($CaCO_3$), total	327	109	299	2,760
pH	7.99	7.40	8.84	9.04
Iron	<0.007	<0.007	<0.007	<0.007
Manganese	<0.002	<0.002	<0.002	<0.002
Calcium	71.3	27.8	28.9	47.8
Magnesium	80.4	16.3	120	1,700
Sodium	271	49.1	424	5,360
Potassium	41.7	7.7	54.6	968
Carbonate	<1	<1	29	707
Bicarbonate	400	134	306	1,930
Sulfate	626	119	1,040	11,500
Chloride	124	24.7	171	2,800
Fluoride	0.14	0.060	NA	NA
Nitrate + Nitrite as N	0.35	0.02	.05	0.27
Silica	4.86	2.13	6.01	17.8
Ammonia as N	0.14	0.087	0.152	1.04
Hydroxide	<1	<1	<1	<1
Phosphorus, total	0.153	0.139	0.052	0.625
Chemical oxygen demand	67	10	75	755
TOC	12.2	4.6	18.7	557
Hardness (total), gr/gal	30	8	33	416
Suspended Solids, total	<5	<5	<5	NA
Turbidity, NTU	1.86	1.7	6.4	16
Percent sodium	51.1	42.1	59.1	58.1
Sodium adsorption ratio	5.22	1.83	7.76	27.6

Note: Results in mg/L unless otherwise noted.
µS/cm = microsiemens/centimeter.
$CaCO_3$ = calcium carbonate
gal = gallon
gr = grains
NTU = nephelometric turbidity unit.
NA = not analyzed.
ppm = parts per million.
TOC = total organic carbon

The FT process simulations were conducted in BCT's process simulator in Laramie, Wyoming, using procedures developed from previous FT research. This unit (figure 2) has computer-operated temperature control and data acquisition functions that are able to simulate daily temperature cycles typical of the Devils Lake area. The simulation procedure follows:

1. Initially, the feedwater pond was charged with a known volume of Devils Lake water.

2. The refrigeration unit controls were programmed to simulate the monthly average daily temperature cycles and atmospheric conditions typical of the Devils Lake area. The temperature in the refrigeration unit was logged hourly. The conditions for each month with subfreezing temperatures were run for a 72-hour duration, making the total time of simulation testing approximately 18 days.

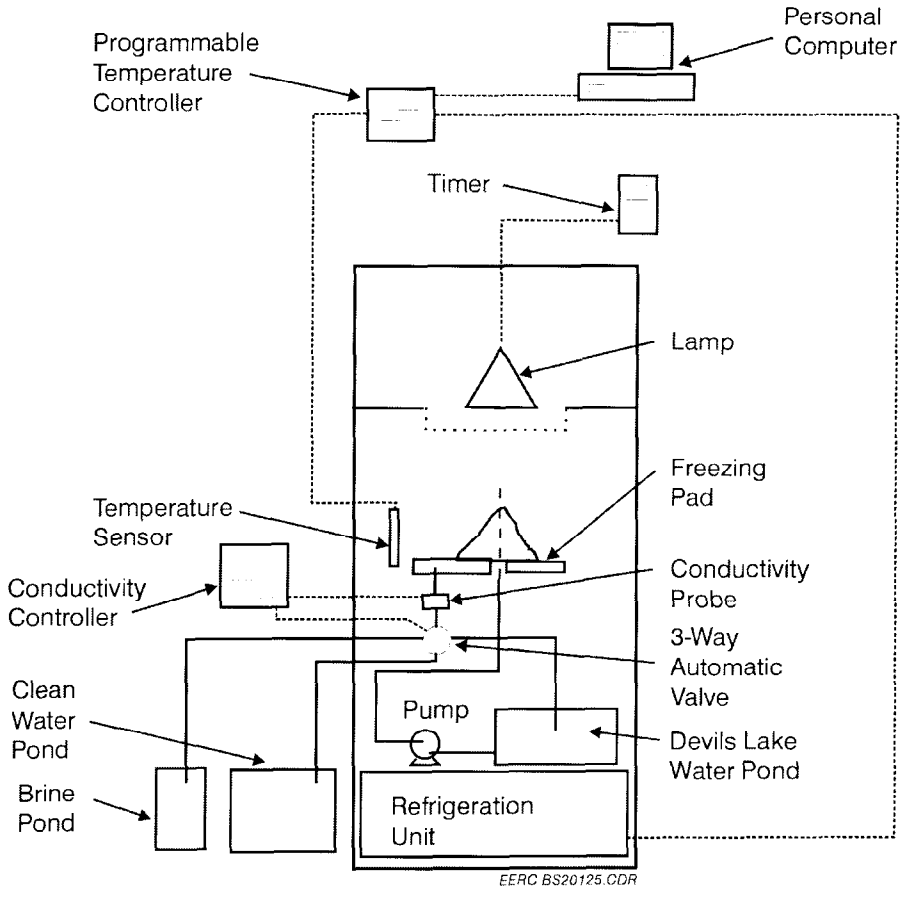


Figure 2.—Refrigeration unit configuration for laboratory-scale FT water purification process simulator.

3. Water was pumped automatically from the feedwater pond to the freezing pad (FP) when the ambient temperature in the simulator promoted freezing, thus forming an ice pile.

4. Runoff from the FP was automatically diverted to either the clean water or brine pond (BP), based on its electrical conductivity (EC). When the simulator temperature promoted freezing, runoff from the pad had concentrated contaminant values (higher EC) and was diverted to the BP. When the temperature promoted melting, runoff from the pad had reduced contaminant values (lower EC) and was diverted to the TW pond.

5. Water was added to the feedwater pond as needed. The amounts of contaminated water added and the volume of TW generated were recorded. The heavy brine that was produced was collected during the experiment. Intermediate brine that was produced was recycled to the feedwater pond for refreezing.

6. Upon completion of the simulation, composite samples of the purified water and intermediate and concentrated brine were collected for analysis.

Simulation Testing Results

A 30-gallon sample of Devils Lake water from Creel Bay was collected and shipped to BCT. FT simulation tests were performed using this water as feedstock. Samples of each of the simulation waters from the simulation test were submitted to the NDDH Chemistry Laboratory and the EERC Analytical Research Laboratory for analysis. The NDDH analytical results (table 1) indicated that total dissolved solids (TDS) values for the simulation testing were as follows: feed – 1,415 parts per million (ppm), treated – 313 ppm, intermediate – 2,020 ppm, and brine – 24,000 ppm. The EERC analytical results were slightly higher for each of the samples. Results from simulation tests at BCT were used to size the demonstration FT plant.

Additional FT simulation data are provided in appendix A. The simulator set point temperature and simulator temperatures (table A-1 and figure A-1) are provided. Summaries of the simulation log, mass balance, and TDS balance (table A-2, figures A-2 and A-3) are also provided, along with the complete analytical results.

SITE SELECTION, PERMITTING, PLANT DESIGN, AND CONSTRUCTION

Site Selection and Permitting

The original site selected for placement of the FT demonstration plant consisted of approximately 80 acres. After the EERC and BCT sized the commercial plant, the demonstration plant was sited to allow its eventual incorporation into the commercial plant. The demonstration site is 600 feet by 700 feet, which is an area of roughly 10 acres. The corners of the demonstration site were located by survey to allow the owner of the land to use the remaining land as a borrow site for an ongoing levee construction project.

The city of Devils Lake has negotiated a 2-year lease with an option-to-buy contract with the owner, Leo Wanzek, Fargo, North Dakota. Under the terms of the agreement, Devils Lake leases the 10 acres on a year-by-year basis for 2 years, at which time it can exercise the option to buy the land plus any additional land needed for the commercial plant.

A State of North Dakota Temporary Water Permit No. 980705 was granted on July 15, 1998, by the North Dakota State Water Commission for the FT demonstration to use up to 16 million gallons of Devils Lake water between October 1, 1998, and May 31, 1999.

A North Dakota Office of Intergovernmental Assistance environmental assessment was conducted by the North Central Planning Council under the direction of Rick Anderson. It was completed on August 29, 1998, and funds were released.

A NDDH Environmental Health Section approved the plans and specifications for the FT demonstration project ponds on September 11, 1998.

A Reclamation environmental assessment was completed and approved on December 9, 1998, and funds were released (appendix B).

Approval to discharge the recombined process waters was given by the NDDH Division of Water Quality on January 11, 1999. Recombined process waters were discharged under North Dakota Pollution Discharge Elimination System (NDPDES) Permit No. NDG070072.

Plant Design and Construction

Demonstration and commercial plant pond sizes were determined on the basis of preliminary results from simulation tests. Six ponds were constructed for the demonstration: two 1-acre freezing pads (FP1 and FP2), one ½-acre holding/recycle pond (HP), one ½-acre BP, and two ½-acre TW ponds.

Both FP and the water ponds (except for one TW pond) were lined with high-density polyethylene (HDPE) liners. Pond liners were sized and specified by BCT to be 18 mil. Permalon PLYX210 single-piece HDPE liners were manufactured by Reef Industries, Inc. (figure 3).

During September 1998, ground surface elevation contours were surveyed, and nine test holes were dug across the demonstration site. Groundwater elevations were monitored for approximately 2 weeks, beginning in late September and concluding in early October, using the ground surface contours and the test holes. The demonstration ponds were designed and sited on the basis of groundwater elevation observations.

EERC BS19867.CDR

Figure 3.—HDPE liner in brine pond.

From October through December 1998, the ponds were constructed and lined; the pump houses were built off site, delivered, and sited; and all piping, pumps, valves, flowmeters, and instrumentation were installed. To provide power to the facility, a 7,200-volt electrical service was installed to the demonstration site by Nodak Rural Electric Cooperative. Onsite electrical service was installed by a local electrical contractor. A 10- × 50-foot trailer was located at the site for office and laboratory purposes, and an 8- × 30-foot travel trailer was provided for operations crew quarters.

In addition to onsite construction, the intake structure and feed line to the demonstration facility were installed. Figure 4 shows the installation of the intake structure; figure 5 shows the feed line after installation.

The piping associated with each FP was designed and constructed to allow for application of water to the FP by way of 16 upright sprays. These sprays were split into four laterals, each with four upright sprays. The four laterals were plumbed to a common header that was fed by a single pipe from all of the system pumps. figures 6 and 7 show the piping associated with FP1.

The demonstration system consisted of four pumps, each with a primary duty: one pump to bring water into the facility from Creel Bay; a second pump to recycle water on FP1; a third to pump to recycle water on FP2; and the fourth to deliver water back from the TW ponds. In addition, manifold and header systems were designed and installed to allow the pumps to remove and deliver water from any pond/pad to any other pond/pad. appendix C contains the design drawings.

Figure 4.—Installation of FT intake structure.

EERC BS19869.CDR

Figure 5.—FT feed line after installation.

EERC BS19825.CDR

Figure 6.—FP1 upright spray locations.

EERC BS19824.CDR

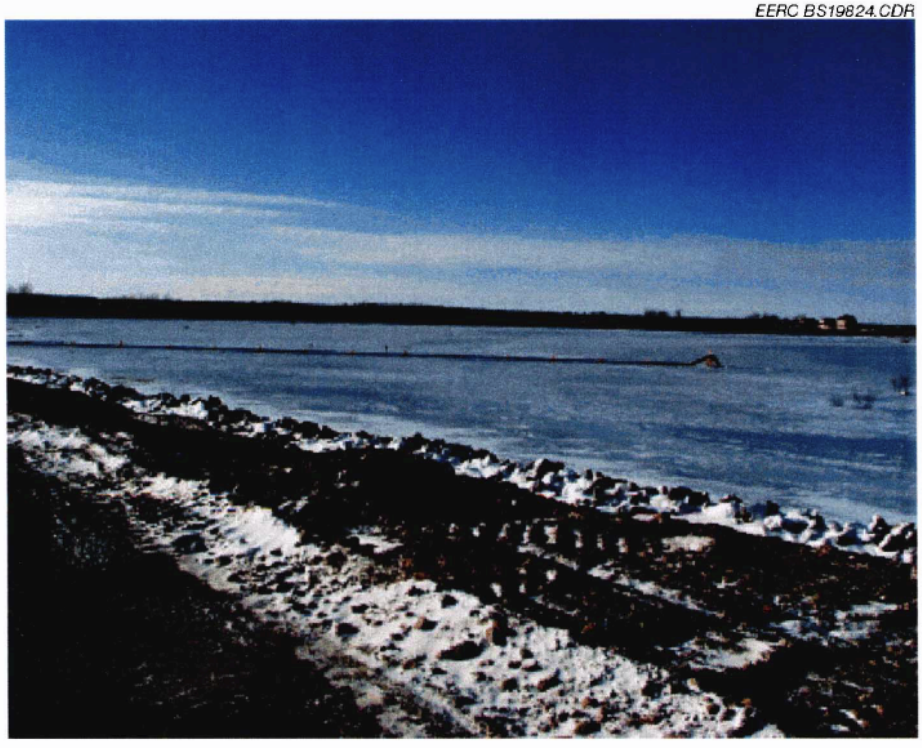


Figure 7.—FP1 upright sprays and piping.

PLANT STARTUP, SHAKEDOWN, AND OPERATION

Plant Startup and Shakedown

The demonstration plant shakedown began on December 28, 1998. From December 28, 1998, to January 1, 1999, approximately 630,000 gallons of Devils Lake water was pumped from Creel Bay to the demonstration site holding pond. Application of Creel Bay water to FP1 was started on January 1, 1999, at a flow rate ranging from 90 to 135 gallons per minute (gpm), utilizing 4 of the 16 upright sprays (figure 8). From January 1 to January 7, 1999, several operational spray configurations were tested on FP1 to determine the best configuration to bring FP2 on-line. On January 7, 1999, FP2 was brought on-line, initially utilizing 12 of the 16 upright sprays.

In the bench-scale simulation performed prior to the demonstration phase, a correlation between EC and TDS was established to make operational decisions using in-line EC instrumentation without having to perform a laboratory TDS analysis. For operational decisions, TDS was taken to be approximately 90-percent of the EC concentration, measured with the handheld portable EC meter. TDS analyses were performed in the field laboratory throughout the demonstration to confirm and verify the EC-TDS relationship.

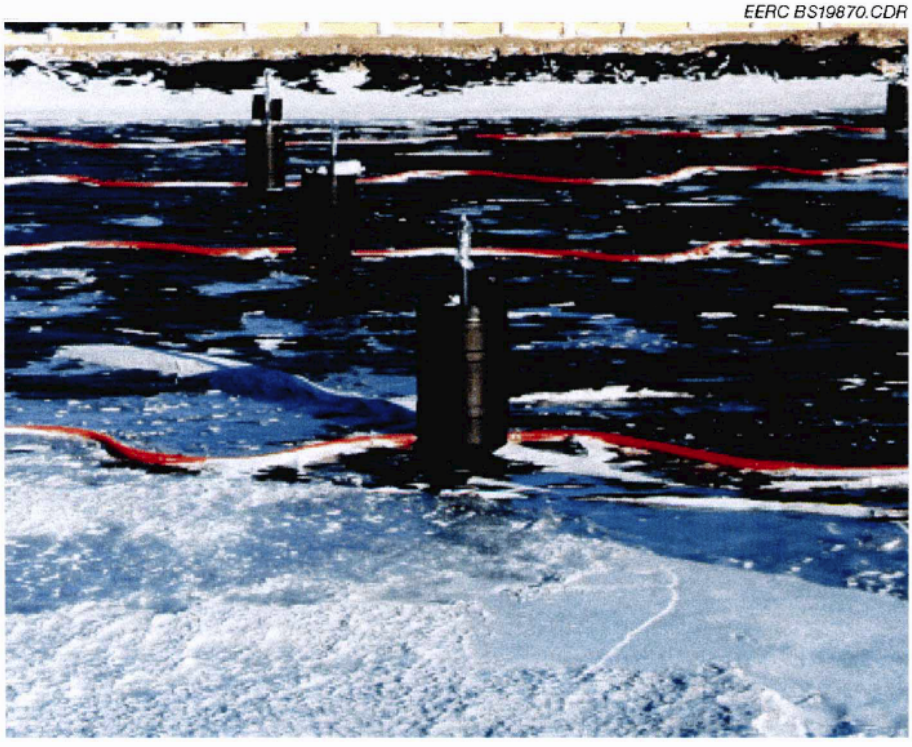


Figure 8.—Upright sprays at the FT demonstration plant.

Plant Operation

On the basis of testing performed during the startup and shakedown phase, operation consisted of spraying Creel Bay water via eight upright sprays on FP1. Application of Creel Bay water to FP2 was started on January 7, 1999, via 12 sprays (figure 9). Although operation of FP1 indicated application of Creel Bay water via 8 uprights was adequate, FP2 was operated via 12 sprays instead of 8 because of a leaking valve.

Typical operation consisted of applying Creel Bay water until sufficient water had migrated through the ice pile and accumulated at the bottom of the FP, at which time water was pumped from the bottom of the FP and reapplied to the ice pile via the upright sprays. When insufficient water existed in the bottom of the FP to recycle, fresh Creel Bay water was applied to the ice pile. This scenario continued until the TDS reached a target level, typically 12,000 ppm or greater. Upon reaching the target TDS level, water was pumped from the bottom of the FP to the BP. Brine pumping continued until either the FP was pumped dry or the TDS level dropped below the target level.

Throughout the FT demonstration, operational and meteorological data (figure 10) were continuously monitored by computer and periodically stored for use in Task 9. In addition, manual measurements were collected every 2 hours to ensure data integrity and to provide a backup to the electronically collected data. appendix D contains a summary and description of the pertinent data collected and a sample operator log sheet.

EERC BS19871.CDR

Figure 9.—Creel Bay water application to FP2.

EERC BS15306

Figure 10.—Installation and setup of the weather station.

From January 1 through March 15, 1999, 4,399,316 gallons of Creel Bay water was pumped to the two FP. Figures 11 and 12 show the accumulation of ice on the FP. During this time, 78,701 gallons of brine was recovered, with a TDS concentration ranging from 9,510 to 13,537 ppm. No TW was recovered prior to March 15, 1999.

On March 15, 1999, system operation transitioned from the freezing phase to the thawing phase. During the thawing phase, the ice piles were allowed to melt, and water was removed from the FP and pumped to the BP, the TW pond, or the holding pond on the basis of its EC. Figure 13 shows the condition of the ice piles at the end of April on FP1, and figure 14 shows the ice piles on FP2 at the end of April.

From March 15 through June 2, 1999, 3,684,290 gallons of TW, having a composite TDS concentration of 450 ppm, was recovered from FP1 and FP2. During the same timeframe, approximately 45,000 gallons of additional brine was recovered for total brine recovery of 123,701 gallons.

As stated in the work plan, TW, intermediate water, and brine produced from the FT demonstration would be remixed onsite to match the EC of the receiving water body (Creel Bay) and discharged. On the basis of samples collected throughout the demonstration, the Creel Bay EC ranged from 1,200 to 2,100 µS/cm. This range then became the discharge target range. Beginning on March 31, 1999, water was discharged to Creel Bay at a flow rate ranging from 99 to 248 gpm until the EC moved out of the target range or until the batch of "mixed" water was gone.

Figure 11.—Accumulation of ice on the freezing pads.

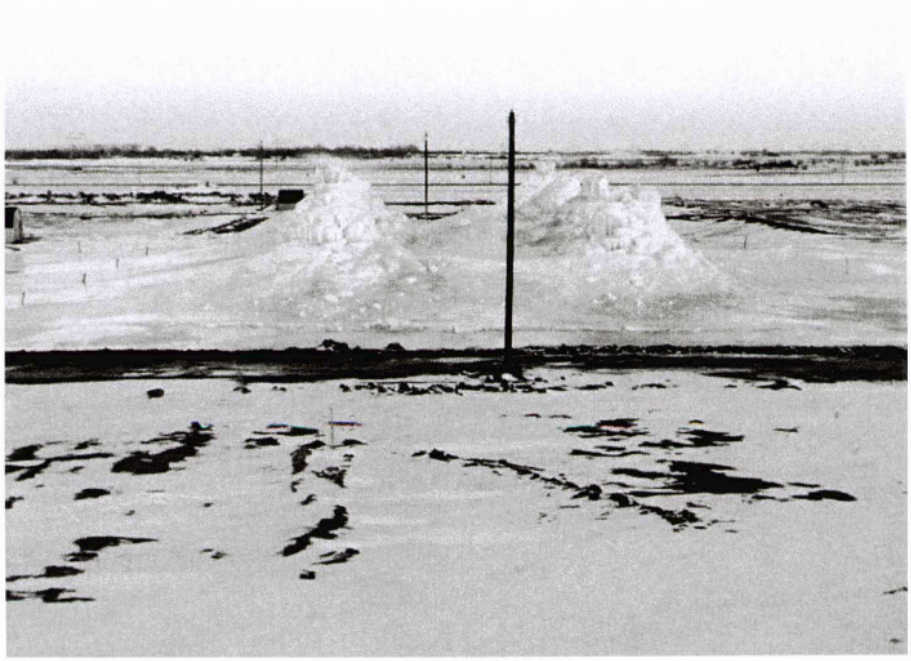


Figure 12.—Accumulation of ice on FP1.

Figure 13.—FP1 ice pile condition (April).

EERC BS19822.CDR

Figure 14.—FP2 ice pile condition (April).

From May 6 to May 9, 1999, the FT demonstration facility experienced several possibly related electrical malfunction incidentes that permanently damaged a majority of the onsite electrical equipment. Although FT operation was completed without replacement of the damaged equipment, the equipment will need to be replaced prior to full-scale FT system operation.

Plant Operation Results

The demonstration FT system was operated from January 1, 1999, through June 2, 1999. January 1, 1999, through March 15, 1999, was considered the freezing phase, and March 15, 1999, through June 2, 1999, was considered the thawing phase of the demonstration.

During the FT demonstration, 4,399,316 gallons of feedwater from Creel Bay was delivered to the two FP. The FT demonstration produced three types of waters: TW having an EC of less than 500 ppm; brine having an EC greater than 10,000 ppm; and intermediate water having an EC between 500 and 10,000 ppm.

From the 4,399,316 gallons of feedwater, 3,684,290 gallons of TW was recovered with an EC of approximately 450 ppm, representing a freshwater yield of approximately 84-percent, by volume. In addition, 123,701 gallons of brine having an EC of approximately 11,500 ppm; 253,507 gallons of nondischargable intermediate; and 182,583 gallons of dischargable intermediate water having a TDS of 2,100 ppm were recovered. A summary of the waters produced during the FT demonstration is shown in table 2. In addition, approximately 7,700 pounds of precipitate (primarily calcium carbonate) was formed and left behind on the FP.

Table 2.—Summary of FT demonstration mass and TDS balances

Description	Volume, (gal)	Percent of total water	TDS Conc., (ppm)	Salt mass, (lb)	Percent of total salt
Treated Water	3,684,290	83.7	450	13,816	27.1
Brine	123,701	2.8	11,500	11,854	23.3
Nondischargable Intermediate Water	253,503	5.8	3,120	6,591	12.9
Dischargable Intermediate Water	182,583	4.2	1,400	2,130	4.2
Precipitate				7,700	15.1
Losses	155,239	3.5	1,390	8,866	17.4
Total	4,399,316	100		50,957	100

During the melting of the ice piles, the TDS concentrations of the melt were estimated from the EC of the melt. The TDS concentration of FP1 melt, as a function of the volume of melt recovered, is provided in figure 15. The figure shows a general asymptotic trend in the decline of the TDS concentration of the ice melt as the melt volume increases. This behavior is typical in the FT process. Interestingly, the TDS concentration of FP1 melt dropped dramatically, then significantly rebounded on March 27, 1999, and on April 11, 1999. Large fluctuations deviating from a normal asymptotic decline are unusual, based upon previous experience with the process. The deviations were a result of air bubbles that developed under the FP liners. The air bubbles inhibited complete recovery of melt.

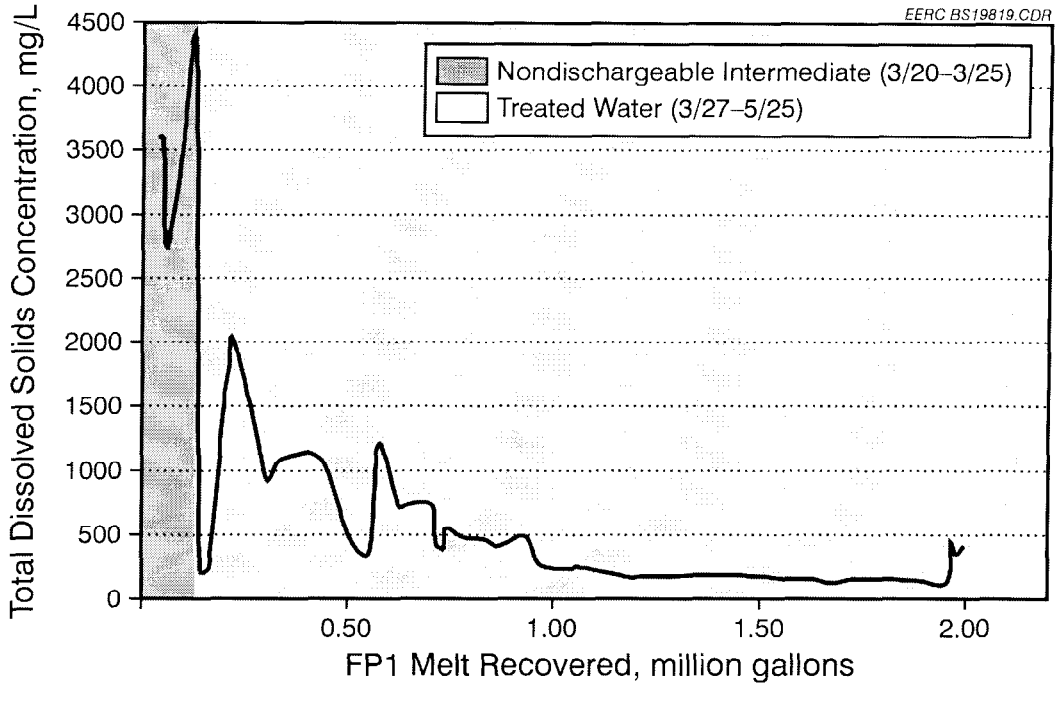


Figure 15.—TDS concentration of FP1 melt versus melt recovery.

The TDS concentration of FP2 melt, as a function of the volume of melt recovered, is provided in figure 16. The fluctuations in the asymptotic decline of the TDS concentration also occurred during the melting of FP2, but they are not as severe as in the FP1 melt curve.

Meteorological Data

Beginning on January 6, 1999, meteorological data from the onsite weather station were continuously monitored on the project computer. Except for an occasional computer glitch or power interruption, meteorological data were saved on the project computer at 1-minute intervals until April 1, 1999, when a power problem rendered most of the onsite electrical equipment useless. A 1-hour interval summary of the meteorological data collected during the demonstration is shown in appendix E.

Ambient temperatures observed during the FT demonstration averaged 16.9°F and ranged from -27.2 °F on January 12, 1999, to 52.0°F on March 30, 1999. Wind speed ranged from 0.0 to 40.3 miles per hour (mph). Wind direction was predominantly from the southeast and northwest.

Precipitate Analysis

During the thawing phase of the demonstration, a greyish-white precipitate was noted when the ice piles began to melt. A sample of the precipitate was collected and reserved for further study. Laboratory experiments performed at the demonstration site established that the precipitate did not redissolve in water, but would redissolve in a weak acid such as vinegar.

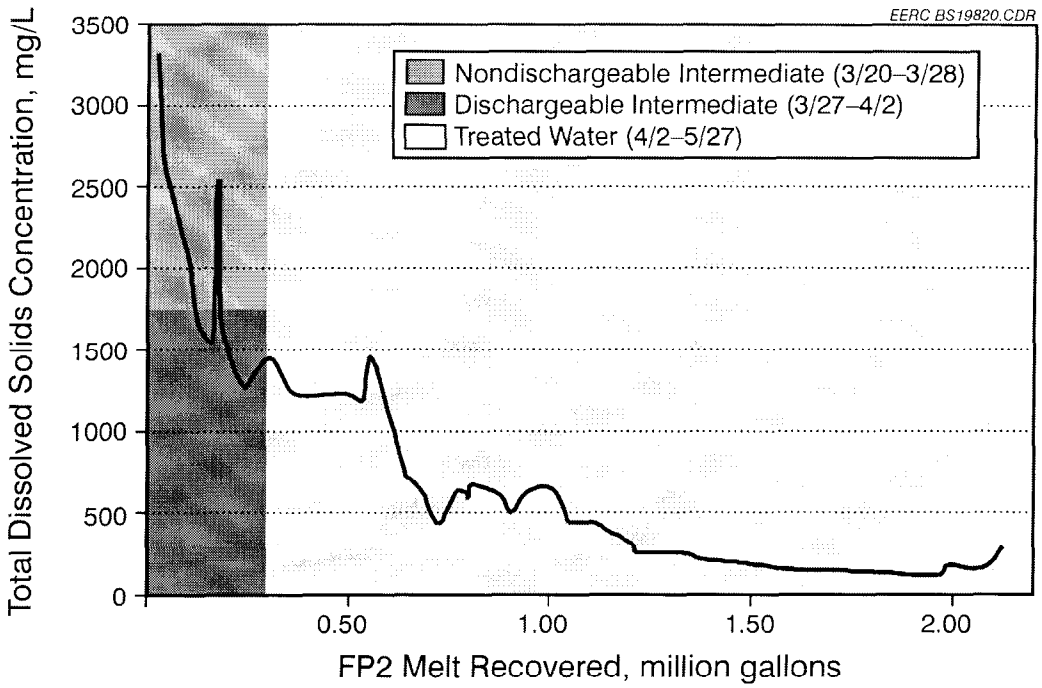


Figure 16.—TDS concentration of FP2 melt versus melt recovered.

The precipitate was initially examined at the EERC utilizing an energy-dispersive system on a scanning electron microscope to grossly identify precipitate components. A more thorough examination of the precipitate utilizing x-ray diffraction (XRD), x-ray fluorescence (XRF), and inductively coupled plasma–atomic emission spectroscopy (ICP–AES) techniques was performed at the EERC's laboratories. EERC analysis indicated that the precipitate was calcium carbonate (calcite). In addition to the presence of calcium, EERC analysis indicated the presence of silicon. The silicon was attributed to the native soils blowing onto the pads. Copies of the EERC laboratory analysis of the precipitate are included in appendix F.

Detailed Chemical Analysis of Demonstration Waters

To thoroughly assess the chemical and physical makeup of the separated waters produced from the demonstration, water samples from the unlined TW pond, the lined TW pond, the BP, and from Creel Bay were collected and submitted to NDDH for analysis.

On June 2, 1999, one water sample from the unlined TW pond, one water sample from the lined TW pond, and one brine sample were collected and submitted to NDDH for analysis. On June 14, 1999, one water sample was collected from Creel Bay and submitted to NDDH for analysis. Analytical parameters for the Creel Bay (feed) water and the TW samples are shown in table 3; analytical parameters for the brine sample are shown in table 4. Copies of the laboratory results are included in appendix G.

A comparison of the influent (Creel Bay water) versus the brine and TWs was performed (table 5). This summary examines the change in physical and chemical characteristics of the Creel Bay after FT treatment. Figures 17 and 18 graphically represent the change in characteristics between the influent (Creel Bay water) and the TWs and between the influent (Creel Bay water) and the brine.

As expected, TDS, conductivity, and most of the associated analytes were reduced in the TW and increased in the brine. Several anomalies did emerge from the comparison. As shown on figure 19, iron and manganese concentrations in the unlined TW pond increased to a level higher than that of the influent sample. This may be attributed to interaction between groundwater and TW in the unlined pond, or the iron and manganese anomaly may be as simple as an erroneous result due to sampling protocol. In addition, the turbidity in the unlined TW pond was higher than the turbidity in the lined TW pond as a result of the pond soils mixing and becoming suspended in the TW.

A comparison was also made between the FT demonstration TW and the city of Devils Lake's municipal drinking water (prior to treatment) utilizing the chemical analysis performed by NDDH. It is displayed in table 6. These raw waters are also correlated in the same table with the pertinent U.S. Environmental Protection Agency (EPA) National Secondary Drinking Water Regulations (NSDWR). The NSDWR are nonenforceable guidelines regulating contaminants that may create undesirable cosmetic or aesthetic effects.

This summary relates the quality of the FT demonstration TW with the city of Devils Lake's current municipal drinking water supply. As shown in figure 19, the TDS concentration of the water well samples was above the EPA NSDWR, while both FT samples were well below the EPA NSDWR. Iron and manganese were also of interest, in that the water well samples were above the EPA NSDWR for manganese, and the samples from Well 12 was above the EPA NSDWR for iron. Both FT samples were below the EPA NSDWR for iron and manganese, except the iron concentration of the unlined TW sample.

Table 3.—Analytical Parameters for the Devils Lake FT Demonstration Plant Feed and TW Samples

Primary inorganic constituents		Pesticides		Other, unregulated, contaminants (organics)	
Antimony	Fluoride	Alachlor	Heptachlor	Chloroform	Dibromomethane
Arsenic	Lead	Atrazine	Heptachlor Epoxide	Bromodichloromethane	4-Chlorotoluene
Barium	Mercury	Carbofuran	Lindane	Chlorodibromomethane	Bromobenzene
Beryllium	Nickel	Chlordane	Methoxychlor	Bromoform	Aldicarb
Cadmium	Nitrate	Dalapon	Oxamyl (Vydate)	1,3-Dichlorobenzene	Aldicarb Sulfoxide
Chromium	Nitrite	Dibromochloropropane (DBCP)	Pentachlorophenol	1,1-Dichloropropene	Aldicarb Sulfone
Copper	Selenium	Dinoseb	Picloram	1,1-Dichloroethane	Aldrin
Cyanide	Thallium	Diquat	Simazine	1,1,2,2-Tetrachloroethane	Butachlor
Secondary inorganic Constituents		Endothall	Toxaphene	1,3-Dichloropropane	Carbaryl
Aluminum	Manganese	Endrin	2,4-D	1,3-Dichloropropene	Dicamba
Chloride	Odor	Ethylene Dibromide (EDB)	2,4,5-TP Silvex	Chloromethane	Dieldrin
Color	Silver	Glyphosate		Bromomethane	3-Hydroxycarbofuran
Corrosivity	Sulfate	**Other synthetic organic chemicals**		1,2,3-Trichloropropane	Methomyl
Foaming Agents	TDS	Acrylamide	Hexachlorobenzene	1,1,1,2-Tetrachloroethane	Metolachlor
Iron	Zinc	Benzo(a)pyrene	Hexachlorocyclopent-adiene	Chloroethane	Metribuzin
Volatile organic chemicals		Di(2-ethylhexyl)adipate	Polychlorinated Biphenyls (PCBs)	2,2-Dichloropropane	Propachlor
Benzene	Monochlorobenzene	Di(2-ethylhexyl)phthalate	Total Trihalomethanes	2-Chlorotoluene	
Carbon Tetrachloride	Styrene	Epichlorohydrin			
1,2-Dichlorobenzene	Tetrachloroethylene	**Microbiological**			
1,4-Dichlorobenzene	Toluene	Total Coliforms (including fecal and *E. coli*)	Heterotrophic Bacteria		
1,2-Dichloroethane	1,2,4-Trichlorobenzene	**Other, unregulated, contaminants (general)**			
1,1-Dichloroethylene	1,1,1-Trichloroethane	Ammonia	pH		
cis-1,2-Dichloroethylene	1,1,2-Trichloroethane	Boron	Alkalinity		
trans-1,2-Dichloroethylene	Trichloroethylene	Calcium	Chemical Oxygen Demand		
Dichloromethane	Vinyl Chloride	Cobalt	Specific Conductance		
1,2-Dichloropropane	Xylenes (total)	Lithium	TOC		
Ethylbenzene		Magnesium	Total Suspended Solids		
		Phosphorus			
		Potassium			
		Sodium			
		Vanadium			

Table 4.—FT demonstration plant brine sample

Ammonia	Selenium
Arsenic	Silver
Barium	Sodium
Cadmium	Sulfate
Calcium	pH
Chromium	Alkalinity
Chloride	Specific Conductance
Lead	Chemical Oxygen Demand
Magnesium	TDS
Mercury	TSS
Phosphorus	TOC
Potassium	

TSS = Total suspended solids

Liner Impacts on Treated Water Quality

In addition to the FT demonstration activities, the lined and unlined TW ponds were left full at the completion of the melting phase, and EC measurements were periodically collected from each of the TW ponds. This was done to assess the interaction of the pond soils with the TW and the corresponding impact on water quality of the TW.

Over a period of 3½ months, from May 6, 1999, to August 25, 1999, EC concentrations in the unlined TW pond went from 0.41 to 0.55 microsiemens per centimeter (mS/cm). This increase in EC concentration, although measurable, may not be significant or warrant the use of a liner in the TW ponds. However, other considerations such as turbidity and groundwater interaction may add to the argument for installing a liner in the TW ponds.

NDPDES Permit Sampling and Reporting

As part of the FT demonstration, the EERC was required to reblend the separated water and return it to Creel Bay. Reblended water had to have an EC within the range of the water being pumped from Creel Bay. Reblended water discharged back to Creel Bay required an NDPDES permit.

To satisfy the NDPDES permit requirements, one grab sample per week was collected during discharge events back to Creel Bay. The grab sample was submitted to NDDH for chemical analysis of pH, total suspended solids, 5-day biochemical demand, EC, temperature, and general chemistry. Chemical analysis results were reported to NDDH on a quarterly basis. The quarterly NDPDES Discharge Monitoring Reports submitted to NDDH are included in appendix H.

Table 5.—Analytical Comparison of FT Demonstration Waters (EPA secondary guidelines and primary inorganic standards)

Analyte, Units	Creel Bay (influent)	Lined Treated Water (effluent)	Unlined Treated Water (effluent)	Brine
Conductivity, µS/cm	1,980	377	498	12,800
TDS, mg/L	1,390	227	315	11,500
Total hardness (as $CaCO_3$), mg/L	498	107	188	3,150
Total hardness, gr/gal	29	6	11	184
pH	8.45	6.75	6.47	9.1
Chemical oxygen demand, mg/L	33	8	5	256
Turbidity, NTU	5.1	1.1	10.1	NA
Iron (Fe), mg/L	0.056	0.024	0.646	**0.007**
Manganese (Mn), mg/L	0.011	0.002	0.015	**0.002**
Calcium (Ca), mg/L	72.5	25.7	50.6	92.3
Magnesium (Mg), mg/L	76.9	10.5	14.9	710
Sodium (Na), mg/L	262	33.3	29.1	2,430
Potassium (K), mg/L	41.2	5.3	3.4	378
Carbonate (CO_3), mg/L	23	1	1	407
Bicarbonate (HCO_3), mg/L	369	110	100	1,150
Sulfate (as SO_4), mg/L	607	79.9	156	5,740
Chloride, mg/L	122	15.8	9.38	1,140
Nitrate + Nitrite, mg/L	0.12	0.02	0.1	0.02

Bold numbers represent concentrations below detection limit.

µS/cm = microsiemens per centimeter

mg/L = milligrams per liter

gr/gal = grains per gallon.

NTU = national turbidity units

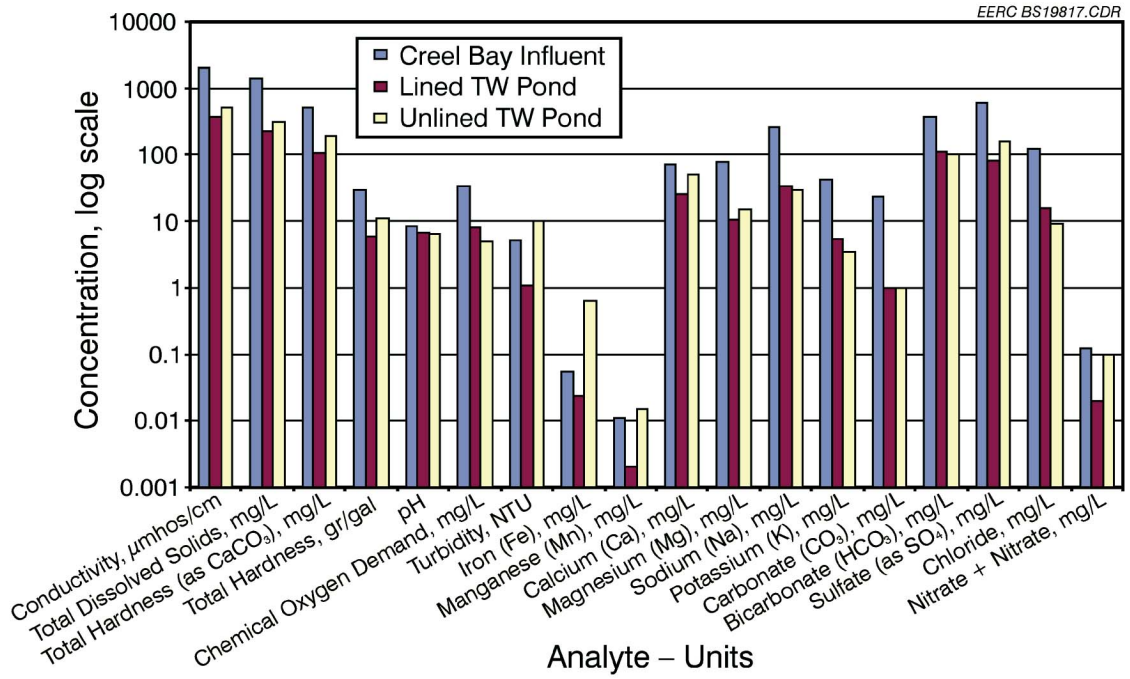


Figure 17.—Chemical analysis comparison, influent (Creel Bay) versus treated water (TW).

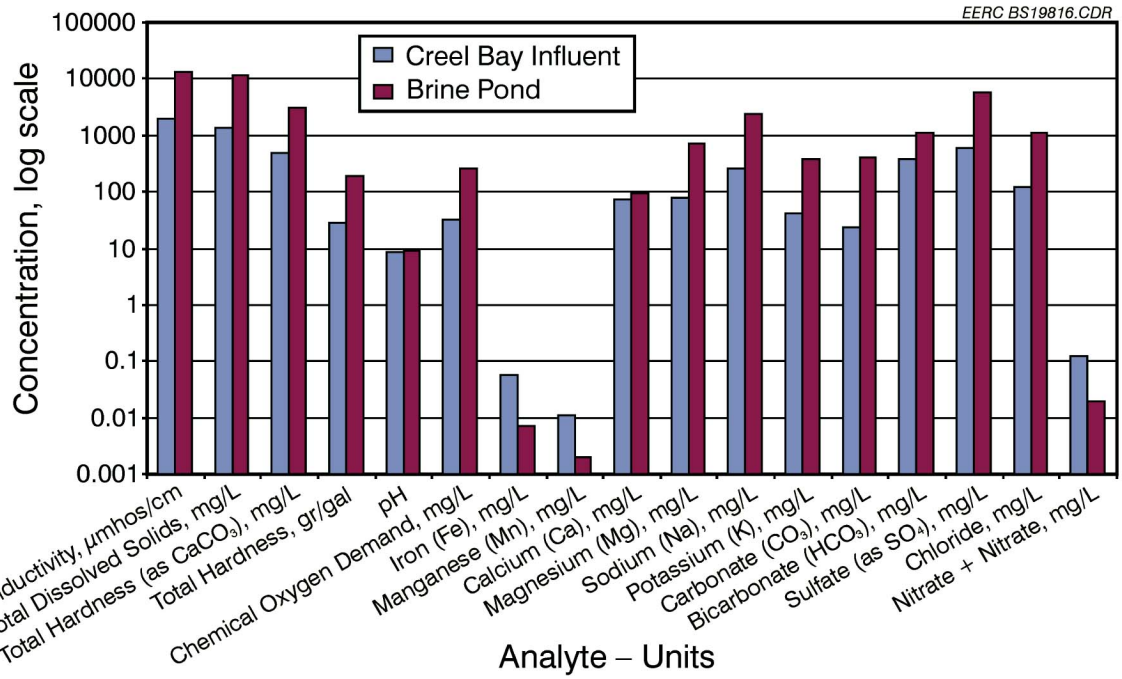


Figure 18.—Chemical analysis comparison, influent (Creel Bay) versus brine.

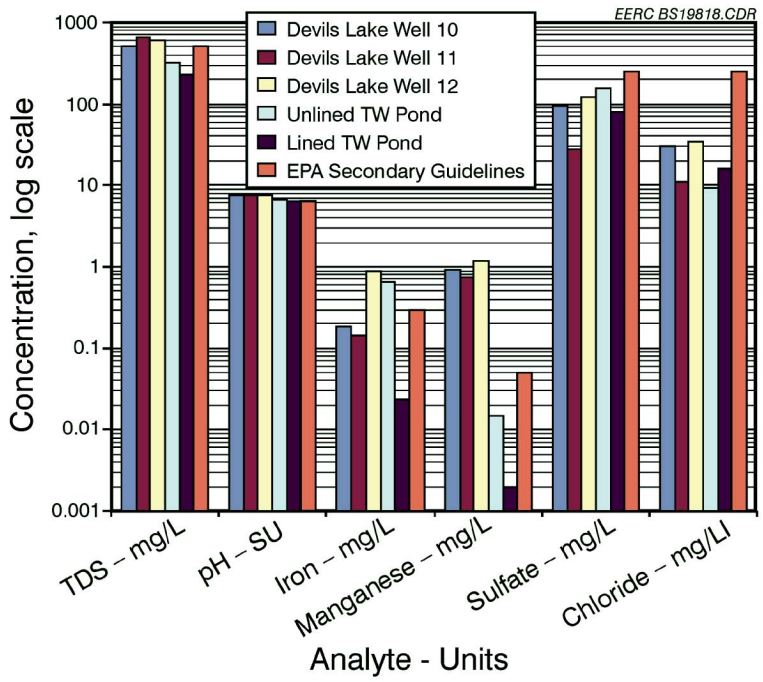


Figure 19.—Chemical analysis comparison, city of Devils Lake well water versus FT-TW.

Table 6.—Analytical Comparison of Raw Waters (City of Devils Lake well water versus FT-TW)

	City of Devils Lake	City of Devils Lake analyte units	City of Devils Lake Well 10	Devils Lake FT unlined TW pond	Devils Lake FT lined TW pond	EPA secondary drinking water guidelines
TDS, mg/L	515	**646**	**592**	315	227	500
pH, SU	7.7	7.7	7.6	6.8	6.5	6.5
Iron, mg/L	0.184	0.143	**0.892**	**0.646**	0.024	0.3
Manganese, mg/L	0.904	**0.757**	**1.18**	0.015	0.002	0.05
Sulfate, mg/L	94	28	121	156	79.9	250
Chloride, mg/L	30.1	10.9	34.5	9.38	15.8	

Bold numbers represent results not within the EPA Secondary Drinking Water Guidelines.
City of Devils Lake well samples were collected on April 26, 1989.

PLANT PERFORMANCE ASSESSMENT, ECONOMIC EVALUATION, AND INTEGRATION INTO FLOOD MITIGATION PLANS

Plant Performance Assessment

On the basis of the data presented in appendix G, the FT demonstration system operated at Devils Lake, North Dakota, was successful in reducing salt concentrations in Devils Lake water to acceptable levels, compared to other raw water sources.

The FT demonstration system produced approximately 3.7 million gallons of treated water (TW) from approximately 4.4 million gallons of influent from Creel Bay, resulting in an 84-percent TW yield. In addition, approximately 124,000 gallons of brine was produced, with the balance of the 4.4 million gallons being considered intermediate water. On the basis of earlier estimates, a commercial-scale FT plant would need to process approximately 110 million gallons of raw water to produce 93 million gallons of TW. On the basis of the annual water use reports for 1996 and 1997 (submitted to NDDH by the city of Devils Lake), 90 million gallons of TW would satisfy approximately 3 months of water usage demand for the city of Devils Lake (appendix I). In addition, figures 20 and 21 show the water demand for the city of Devils Lake for 1995 and 1997, respectively.

Treated water from the natural FT process has two primary uses: (1) as a raw water supply for municipal use; and (2) as a source of water for nonconsumptive uses (irrigation, industrial process water, livestock watering, etc.).

Analysis of the FT demonstration TW indicated better water quality than the groundwater supply currently used by the city of Devils Lake for municipal use (appendix J). Use of the TW from the FT demonstration for human consumption would require a treatment process similar to treating a raw surface water source. Depending on surface water characteristics, treatment would typically involve one of the two following treatment schemes: (1) screen filtration, chemical coagulation, flocculation, sedimentation, granular filtration, and disinfection; or (2) screen filtration, chemical coagulation, flocculation, sedimentation, recarbonation, granular filtration, and disinfection. Use of the TW from the FT demonstration for secondary uses (such as irrigation, industrial uses, or livestock uses would not typically require any additional treatment).

DESIGN AND CAPITAL COST OF COMMERCIAL FREEZE-THAW FACILITY

As part of this project, a detailed preliminary design for a full-scale commercial FT facility was developed. The commercial FT facility is designed to treat water from Devils Lake, using the demonstrated FT process and conventional water treatment techniques (filtration, disinfection, etc.) to deliver approximately 93 million gallons of potable water each year. Based on demonstrated FT facility performance, approximately 110 million gallons of Devils Lake raw water would require treatment to

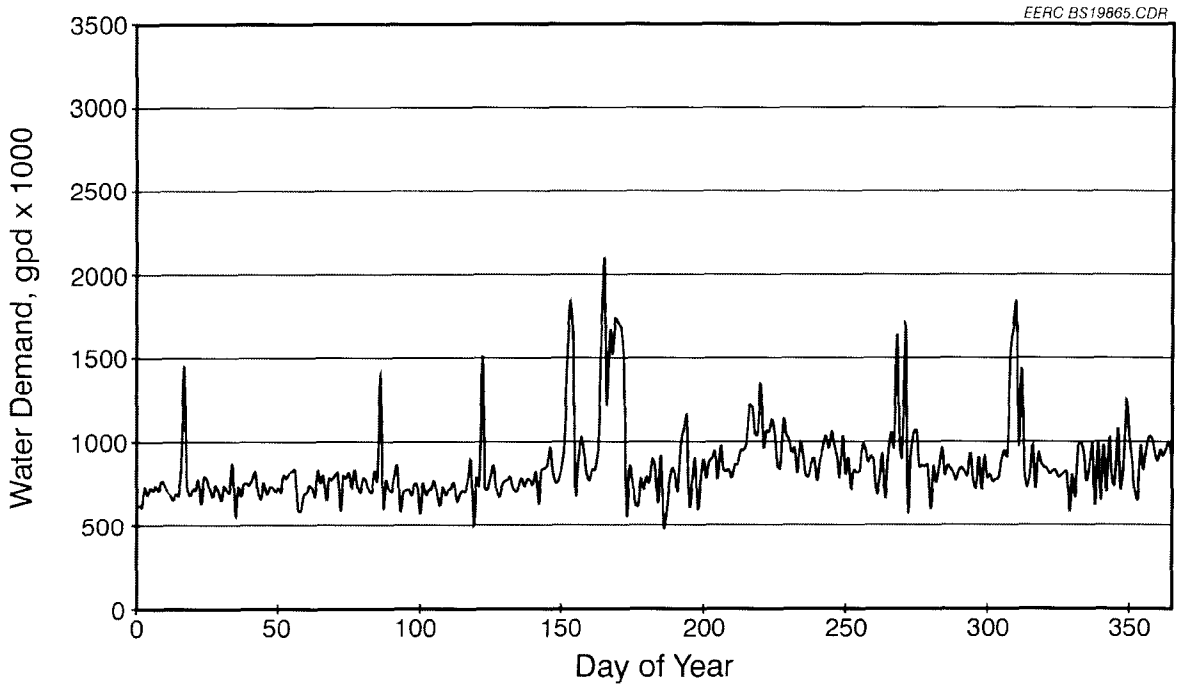


Figure 20.—1995 daily water demand for the city of Devils Lake.

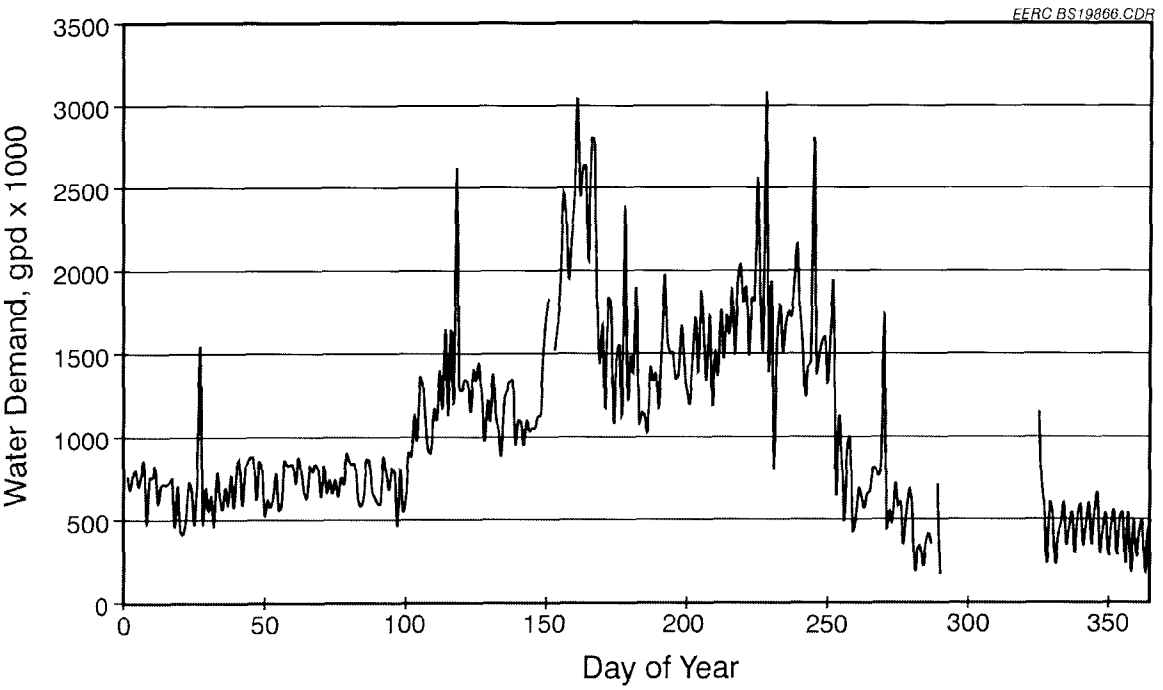


Figure 21.—1997 daily water demand for the city of Devils Lake.

produce 93 million gallons of potable water. The complete commercial FT facility design, including costs, is presented in appendix K.

Integration into Flood Mitigation Plans

Because of the increasing water levels in Devils Lake, portions of the city of Devils Lake's existing water supply infrastructure are covered by water. In addition, the city of Devils Lake is a municipal well field, and its associated water supply lines are located in an easement established with the Devils Lake Sioux in 1963. This easement is scheduled to expire in 2013, and the likelihood of its renewal is uncertain. For these reasons, city and regional officials are evaluating this technology as a viable water supply for the residents of Devils Lake. Figure 22 shows the location of the city of Devils Lake's municipal supply wells and associated water supply line.

SITE RECLAMATION

After the completion of the 1999 operating season, the EERC attempted to secure additional funding to continue operation of the FT demonstration facility. Unfortunately, no funding was secured, and the FT facility at Devils Lake was slated for reclamation. During August and September 2000, all pumping equipment and associated piping was removed from the site. The electrical service up to the transformer onsite was left intact for potential future use by the landowner. An agreement could not be reached with a subcontractor to perform the reclamation earthwork until December 2001, at which time the ponds were filled with onsite stockpile material and borrow from the adjacent property. Efforts to remove the pond liners proved to be unsuccessful; therefore, at the approval of the landowner, the liners were sliced to allow for groundwater movement, and the liners were buried in place. The landowner has approved the site reclamation and provided his acceptance of the work in writing (appendix M).

RECOMMENDATIONS

Based on technical and economic data and results provided in this report, the following recommendations were presented in the draft final report submitted and presented in September 1999.

Option 1

- Replace damaged electrical equipment and necessary devices to prevent a reccurrence.
- Operate the existing FT demonstration facility for another freezing season to verify Year 1 performance results, using the same raw water utilized during Year 1 operation.
- Conduct design modifications and evaluate their effectiveness to reduce operating costs and increase FT system efficiency.
- Utilize city of Devils Lake employees during FT operation to better familiarize them with the FT operation and accomplish hands-on training.

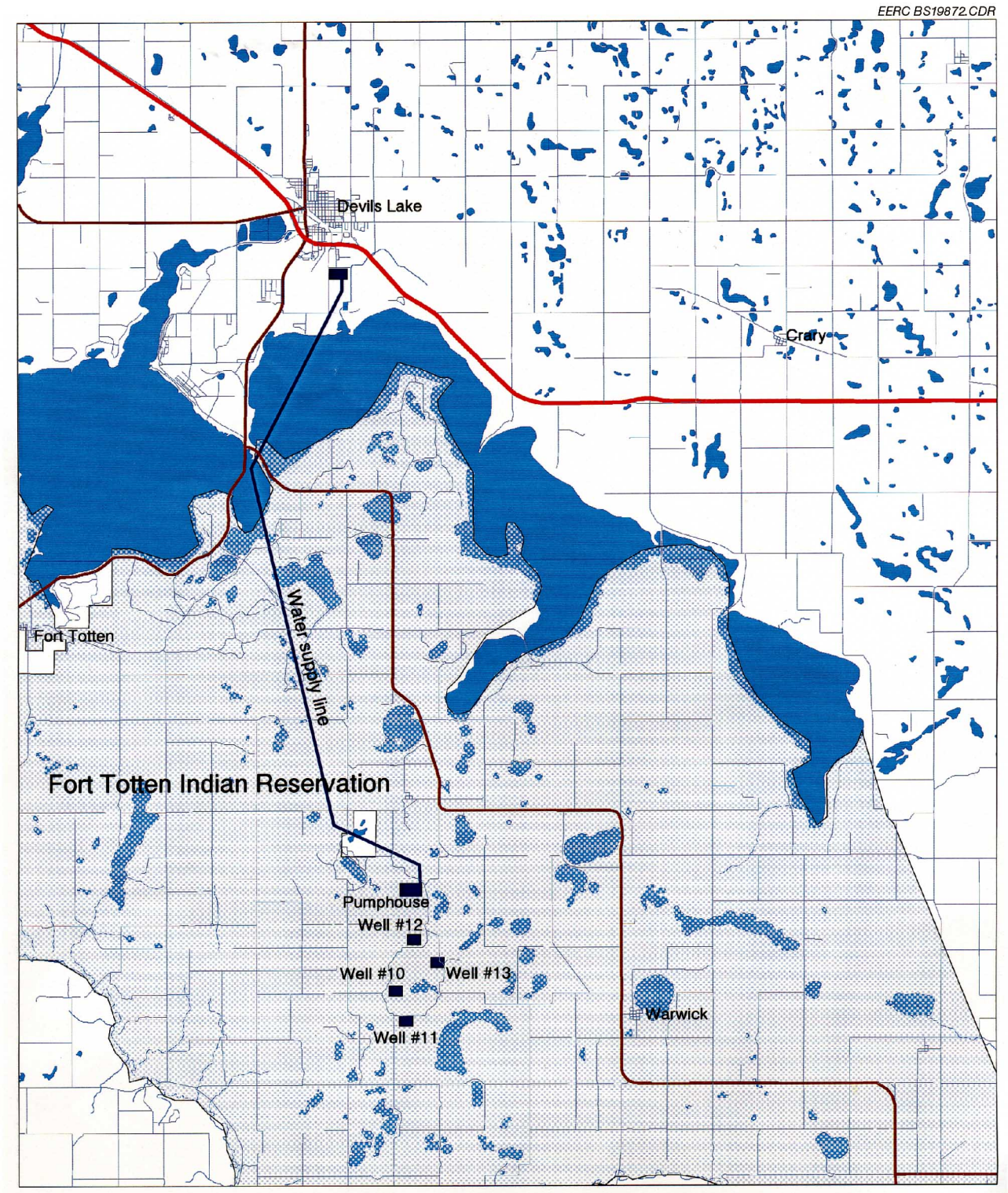


Figure 22.—Map of water supply network for the city of Devils Lake.

- Work with city of Devils Lake officials to identify and secure end user(s) for TW.
- Work with city of Devils Lake officials to identify and secure end user(s) for brine/salts.

Option 2

- Replace damaged electrical equipment and necessary devices to prevent a reccurrence.
- Operate the existing FT demonstration facility for another freezing season, utilizing a different raw water supply such as water from Stump Lake or shallow groundwater.
- Conduct design modifications and evaluate their effectiveness to reduce operating costs and increase FT system efficiency.
- Utilize city of Devils Lake employees during FT operation to better familiarize them with the FT operation and accomplish hands-on training.
- Work with city of Devils Lake officials to identify and secure end user(s) for TW.
- Work with city of Devils Lake officials to identify and secure end user(s) for brine/salts.

Performance of these recommendations was based on successfully identifying and securing additional funding for a second year of operation. Additional funding was not secured; therefore, the FT facility located at Devils Lake was reclaimed starting in August 2000 and ending in December 2001. It is our opinion that the recommendations offered in the draft final report remain valid and that a second year of FT facility operation is still warranted to verify and increase plant performance and reduce operational costs.

The EERC will continue to identify potential sponsors for the demonstration of FT technologies in the future, as we believe this technology has great potential in the field of water desalination.

APPENDIX A

FT SIMULATION RESULTS

Devils Lake Desalinization FT Bench-Scale Simulation Results

Simulation Temperature Profile

The hourly temperature set-point data for simulating the eastern North Dakota climate are provided in Table A-1. The temperatures actually achieved in the desalinization FT bench-scale simulation are presented in Figure A-1 along with the desired simulator temperatures (simulator set point). As the data in the figure illustrate, there were some departures from the desired simulation temperature profiles.

Simulation Log

Following Figure A-1, the simulation log is attached.

Simulation Yields and Results of Chemical Analyses

Simulation mass and TDS balance summaries are provided in Table A-2. In addition, the simulation product mass yields are presented in Figure A-2 and the simulation product TDS yields are presented in Figure A-3. Following Figure A-3, results of chemical analyses of the simulation process streams are provided.

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location

Month	Hour	Average Temperature °C	°F
1	1	-19.6	-3.3
1	2	-20.4	-4.8
1	3	-20.9	-5.7
1	4	-21.1	-6.0
1	5	-20.9	-5.7
1	6	-20.4	-4.8
1	7	-19.6	-3.3
1	8	-18.6	-1.5
1	9	-17.4	.7
1	10	-16.1	3.0
1	11	-14.8	5.3
1	12	-13.6	7.4
1	13	-12.6	9.3
1	14	-11.9	10.7
1	15	-11.4	11.5
1	16	-11.2	11.8
1	17	-11.4	11.5
1	18	-11.9	10.7
1	19	-12.6	9.3
1	20	-13.7	7.4
1	21	-14.8	5.3
1	22	-16.1	3.0
1	23	-17.4	.7
1	24	-18.6	-1.5

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	°F
2	1	-15.9	3.3
2	2	-16.8	1.8
2	3	-17.3	.8
2	4	-17.5	.5
2	5	-17.3	.8
2	6	-16.8	1.8
2	7	-15.9	3.3
2	8	-14.8	5.3
2	9	-13.6	7.6
2	10	-12.2	10.0
2	11	-10.8	12.5
2	12	-9.5	14.8
2	13	-8.5	16.8
2	14	-7.6	18.3
2	15	-7.1	19.3
2	16	-6.9	19.6
2	17	-7.1	19.3
2	18	-7.6	18.3
2	19	-8.5	16.8
2	20	-9.6	14.8
2	21	-10.8	12.5
2	22	-12.2	10.0
2	23	-13.6	7.6
2	24	-14.9	5.3

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	°F
3	1	-8.7	16.3
3	2	-9.5	14.9
3	3	-10.0	14.0
3	4	-10.2	13.6
3	5	-10.0	14.0
3	6	-9.5	14.9
3	7	-8.7	16.3
3	8	-7.6	18.2
3	9	-6.4	20.4
3	10	-5.1	22.8
3	11	-3.8	25.2
3	12	-2.5	27.4
3	13	-1.5	29.3
3	14	-.7	30.8
3	15	-.2	31.7
3	16	.0	32.0
3	17	-.2	31.7
3	18	-.7	30.8
3	19	-1.5	29.3
3	20	-2.6	27.4
3	21	-3.8	25.2
3	22	-5.1	22.8
3	23	-6.4	20.4
3	24	-7.7	18.2

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	°F
4	1	1.4	34.5
4	2	.5	32.8
4	3	-.1	31.8
4	4	-.3	31.5
4	5	-.1	31.8
4	6	.5	32.8
4	7	1.4	34.5
4	8	2.6	36.6
4	9	3.9	39.1
4	10	5.4	41.7
4	11	6.9	44.4
4	12	8.3	46.9
4	13	9.4	49.0
4	14	10.3	50.6
4	15	10.9	51.6
4	16	11.1	52.0
4	17	10.9	51.6
4	18	10.3	50.6
4	19	9.4	49.0
4	20	8.2	46.8
4	21	6.9	44.4
4	22	5.4	41.7
4	23	3.9	39.1
4	24	2.5	36.6

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	°F
5	1	8.2	46.7
5	2	7.0	44.7
5	3	6.3	43.4
5	4	6.1	43.0
5	5	6.3	43.4
5	6	7.0	44.7
5	7	8.2	46.7
5	8	9.6	49.3
5	9	11.3	52.3
5	10	13.1	55.6
5	11	15.0	58.9
5	12	16.7	62.1
5	13	18.2	64.7
5	14	19.3	66.8
5	15	20.1	68.1
5	16	20.3	68.5
5	17	20.1	68.1
5	18	19.3	66.8
5	19	18.2	64.7
5	20	16.7	62.1
5	21	15.0	58.9
5	22	13.1	55.6
5	23	11.3	52.3
5	24	9.6	49.3

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	Average Temperature °F
6	1	13.7	56.6
6	2	12.6	54.7
6	3	11.9	53.5
6	4	11.7	53.1
6	5	11.9	53.5
6	6	12.6	54.7
6	7	13.7	56.6
6	8	15.1	59.1
6	9	16.7	62.0
6	10	18.4	65.1
6	11	20.1	68.2
6	12	21.7	71.1
6	13	23.1	73.5
6	14	24.1	75.4
6	15	24.8	76.6
6	16	25.0	77.0
6	17	24.8	76.6
6	18	24.1	75.4
6	19	23.1	73.5
6	20	21.7	71.1
6	21	20.1	68.2
6	22	18.4	65.1
6	23	16.7	62.0
6	24	15.0	59.1

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	°F
7	1	16.2	61.1
7	2	15.1	59.2
7	3	14.4	58.0
7	4	14.2	57.6
7	5	14.4	58.0
7	6	15.1	59.2
7	7	16.2	61.1
7	8	17.6	63.7
7	9	19.2	66.6
7	10	21.0	69.8
7	11	22.8	73.0
7	12	24.4	75.9
7	13	25.8	78.5
7	14	26.9	80.4
7	15	27.6	81.6
7	16	27.8	82.0
7	17	27.6	81.6
7	18	26.9	80.4
7	19	25.8	78.5
7	20	24.4	75.9
7	21	22.8	73.0
7	22	21.0	69.8
7	23	19.2	66.6
7	24	17.6	63.7

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	°F
8	1	15.0	59.0
8	2	13.9	56.9
8	3	13.1	55.7
8	4	12.9	55.2
8	5	13.1	55.7
8	6	13.9	56.9
8	7	15.0	59.0
8	8	16.5	61.6
8	9	18.2	64.7
8	10	20.0	68.0
8	11	21.8	71.3
8	12	23.6	74.4
8	13	25.0	77.0
8	14	26.1	79.1
8	15	26.9	80.3
8	16	27.1	80.8
8	17	26.9	80.3
8	18	26.1	79.1
8	19	25.0	77.0
8	20	23.5	74.4
8	21	21.8	71.3
8	22	20.0	68.0
8	23	18.2	64.7
8	24	16.4	61.6

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	Average Temperature °F
9	1	9.4	48.9
9	2	8.3	46.9
9	3	7.6	45.7
9	4	7.4	45.3
9	5	7.6	45.7
9	6	8.3	46.9
9	7	9.4	48.9
9	8	10.8	51.4
9	9	12.4	54.3
9	10	14.1	57.4
9	11	15.8	60.5
9	12	17.4	63.3
9	13	18.8	65.8
9	14	19.8	67.7
9	15	20.5	68.9
9	16	20.7	69.3
9	17	20.5	68.9
9	18	19.8	67.7
9	19	18.8	65.8
9	20	17.4	63.3
9	21	15.8	60.5
9	22	14.1	57.4
9	23	12.4	54.3
9	24	10.7	51.3

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	°F
10	1	3.6	38.5
10	2	2.6	36.7
10	3	2.0	35.6
10	4	1.8	35.2
10	5	2.0	35.6
10	6	2.6	36.7
10	7	3.6	38.5
10	8	4.9	40.7
10	9	6.3	43.4
10	10	7.9	46.2
10	11	9.5	49.0
10	12	10.9	51.6
10	13	12.1	53.9
10	14	13.1	55.6
10	15	13.7	56.7
10	16	13.9	57.0
10	17	13.7	56.7
10	18	13.1	55.6
10	19	12.1	53.9
10	20	10.9	51.6
10	21	9.5	49.0
10	22	7.9	46.2
10	23	6.3	43.4
10	24	4.8	40.7

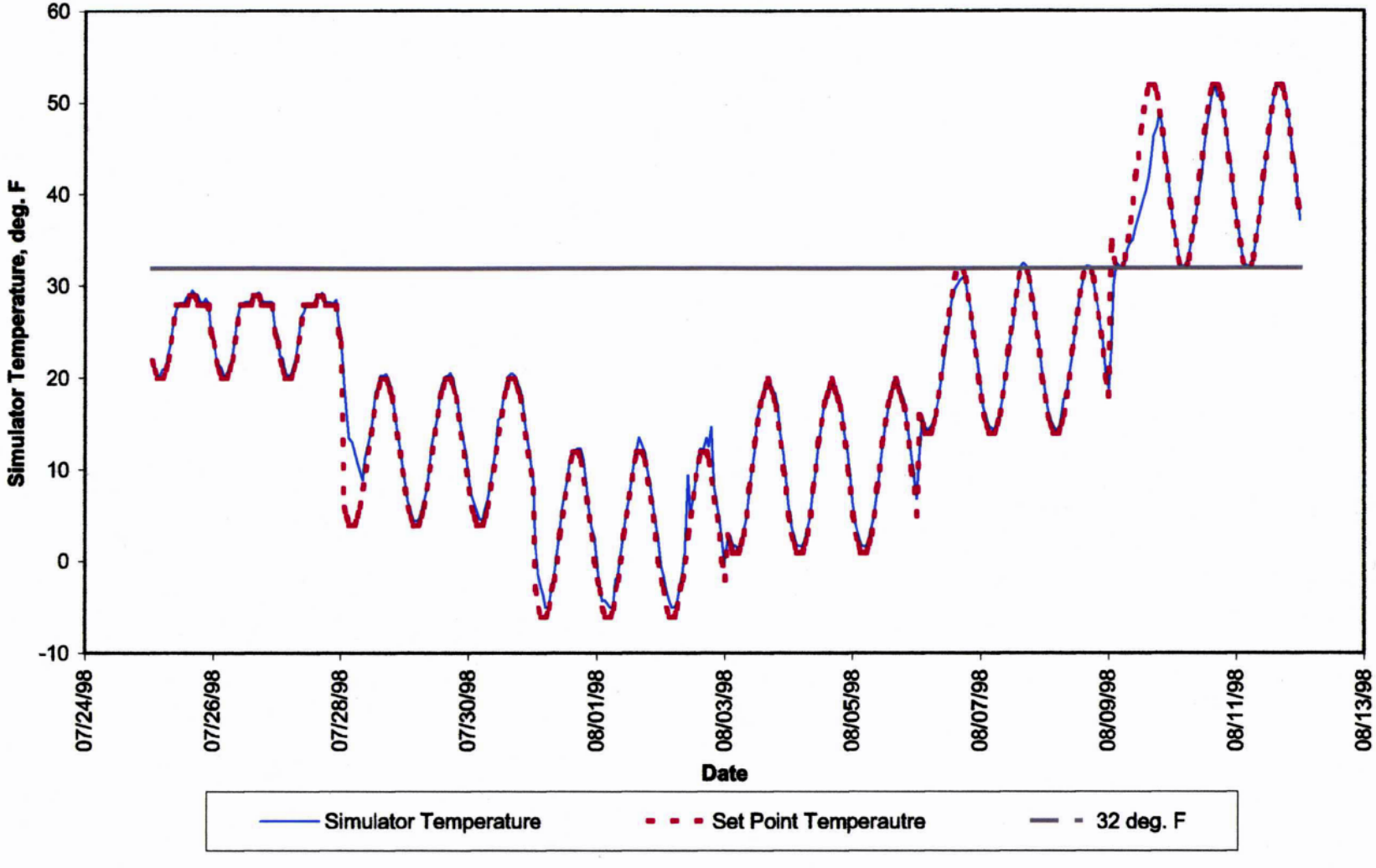
Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	°F
11	1	-5.6	21.9
11	2	-6.3	20.6
11	3	-6.8	19.8
11	4	-6.9	19.6
11	5	-6.8	19.8
11	6	-6.3	20.6
11	7	-5.6	21.9
11	8	-4.7	23.5
11	9	-3.6	25.5
11	10	-2.5	27.5
11	11	-2.3	27.8
11	12	-2.2	28.0
11	13	-2.1	28.3
11	14	-2.0	28.4
11	15	-1.9	28.5
11	16	-1.9	28.6
11	17	-1.9	28.5
11	18	-2.0	28.4
11	19	-2.1	28.3
11	20	-2.2	28.0
11	21	-2.3	27.8
11	22	-2.5	27.5
11	23	-3.6	25.4
11	24	-4.7	23.5

Table A-1. Daily Atmospheric Temperature Cycles for an eastern North Dakota location (continued)

Month	Hour	Average Temperature °C	°F
12	1	-14.5	5.9
12	2	-15.2	4.6
12	3	-15.6	3.8
12	4	-15.8	3.6
12	5	-15.6	3.8
12	6	-15.2	4.6
12	7	-14.5	5.9
12	8	-13.5	7.6
12	9	-12.5	9.6
12	10	-11.3	11.7
12	11	-10.1	13.8
12	12	-9.0	15.8
12	13	-8.0	17.5
12	14	-7.3	18.8
12	15	-6.9	19.7
12	16	-6.7	19.9
12	17	-6.9	19.7
12	18	-7.3	18.8
12	19	-8.0	17.5
12	20	-9.0	15.8
12	21	-10.1	13.8
12	22	-11.3	11.7
12	23	-12.5	9.6
12	24	-13.6	7.6

Figure A-1. FT Simulator Temperature vs Time



B.C. Technologies, Ltd.

Freeze-Thaw Bench-scale Simulation Log

Project: Devils Lake Desalinization

Feed: Devils Lake Water

onth Simulate	Start Date	Start Time	Feed EC (ms)	Comments
None	07/02/98	09:10		EC meter/controller calibration
None	07/24/98	17:00	1.986	Feed Added - 41,850.4 grams - pH = 7.5
November	07/25/98	00:00		Simulation - Nov. Day 1
				TDS meter - 0 ppm
November	07/26/98	00:00		Simulation - Nov. Day 2
				TDS meter - 4700 ppm
November	07/27/98	00:00		Simulation - Nov. Day 3
				TDS meter - 5000 ppm
		14:20	1.986	Measured sample spill collected from containment
				on 7/24/98 during reactor loading - 5007.2 grams.
		21:25		Thawed feed lines.
December	07/28/98	00:00		Simulation - Dec. Day 1
				TDS meter - 5000+ ppm
		18:00		Increased feedrate.
December	07/29/98	00:00		Simulation - Dec. Day 2
		09:30		Thawed feed line - 10ml lost (est.)
December	07/30/98	0:00		Simulation - Dec. Day 3
				TDS meter - 5000+ ppm
January	07/31/98	00:00		Simulation - Jan. Day 1
		17:10		Power outage - simulator in manual until midnight.
January	08/01/98	00:00		Simulation - Jan. Day 2
				TDS meter - 5000+ ppm
		15:40		Power outage - wrote new program for rest of day.
January	08/02/98	00:00		Simulation - Jan. Day 3
				TDS meter - 5000+ ppm
February	08/03/98	00:00		Simulation - Feb. Day 1
				TDS meter - 5000+ ppm
February	08/04/98	00:00		Simulation - Feb. Day 2
				TDS meter - 3300 ppm
February	08/05/98	00:00		Simulation - Feb. Day 3
				TDS meter - 3700 ppm
March	08/06/98	00:00		Simulation - March Day 1
March	08/07/98	00:00		Simulation - March Day 2
				TDS meter - 3700 ppm
March	08/08/98	00:00		Simulation - March Day 2
				TDS meter - 3700 ppm
April	08/09/98	00:00		Simulation - April Day 1
				TDS meter - 3800 ppm
April	08/10/98	00:00		Simulation - April Day 2
				TDS meter - 5000 ppm
		09:05	20.0	Sample 1 melt collected.
		11:35		Current melt TDS 2600 ppm
		15:45		Current melt TDS 3400 ppm
April	08/11/98	00:00		Simulation - April Day 3
				Current melt TDS 3300 ppm
				Sample 2 melt collected.
		08:35		Current melt TDS 3100 ppm
		14:40		Current melt TDS 2400 ppm
				Sample 3 melt collected.
		21:00		Current melt TDS 1700 ppm
				Sample 4 melt collected.
None	08/12/98	09:30		Current melt TDS 1200 ppm
		12:30		Current melt TDS 800 ppm
				Sample 5 melt collected.
		18:00		Current melt TDS 600 ppm
				Sample 6 melt collected.
		23:50		Current melt TDS 400 ppm - Temp. 40 deg. F
				Sample 7 melt collected.
None	08/13/98	09:30		Current melt TDS 300 ppm
				Sample 8 melt collected.
		21:45		Current melt TDS 200 ppm
				Sample 9 melt collected.
	08/14/98	09:20		Current melt TDS 150 ppm
				Sample 10 melt collected.
None	08/15/98	day		Current melt TDS 200 ppm
				Samples 11 and 12 melt collected.

Table A-2. FT Simulation
Mass and TDS Balance Summaries

	Total Mass, g	% of Mass of Feed	TDS Conc., mg/l	Mass of TDS, g	% of TDS in Feed
Feed	36843		1415	52.1	
Brine	760	2.1%	24000	18.2	35.0%
Intermediate	11441	31.1%	2020	23.1	44.3%
Treated Water	24049	65.3%	313	7.5	14.4%
Losses	593	1.6%		3.3	6.2%

Figure A-2. FT Simulation Product Mass Yields

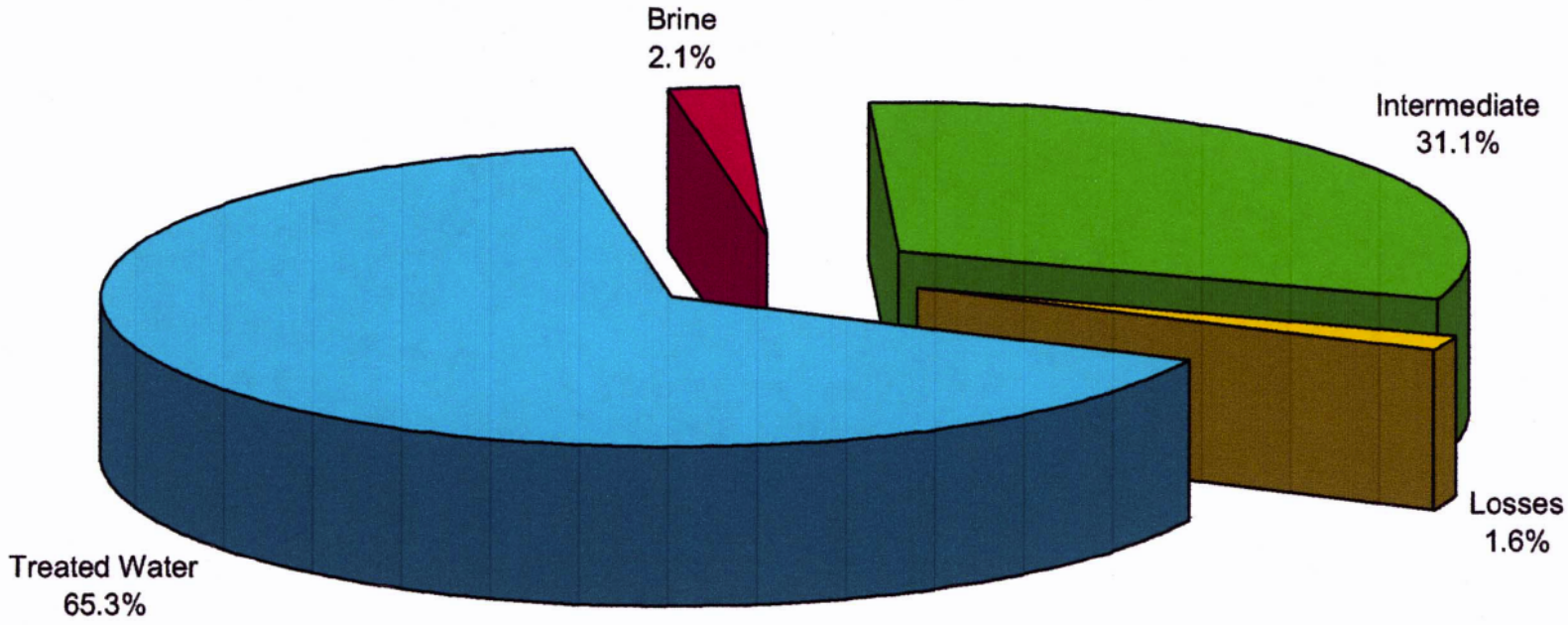
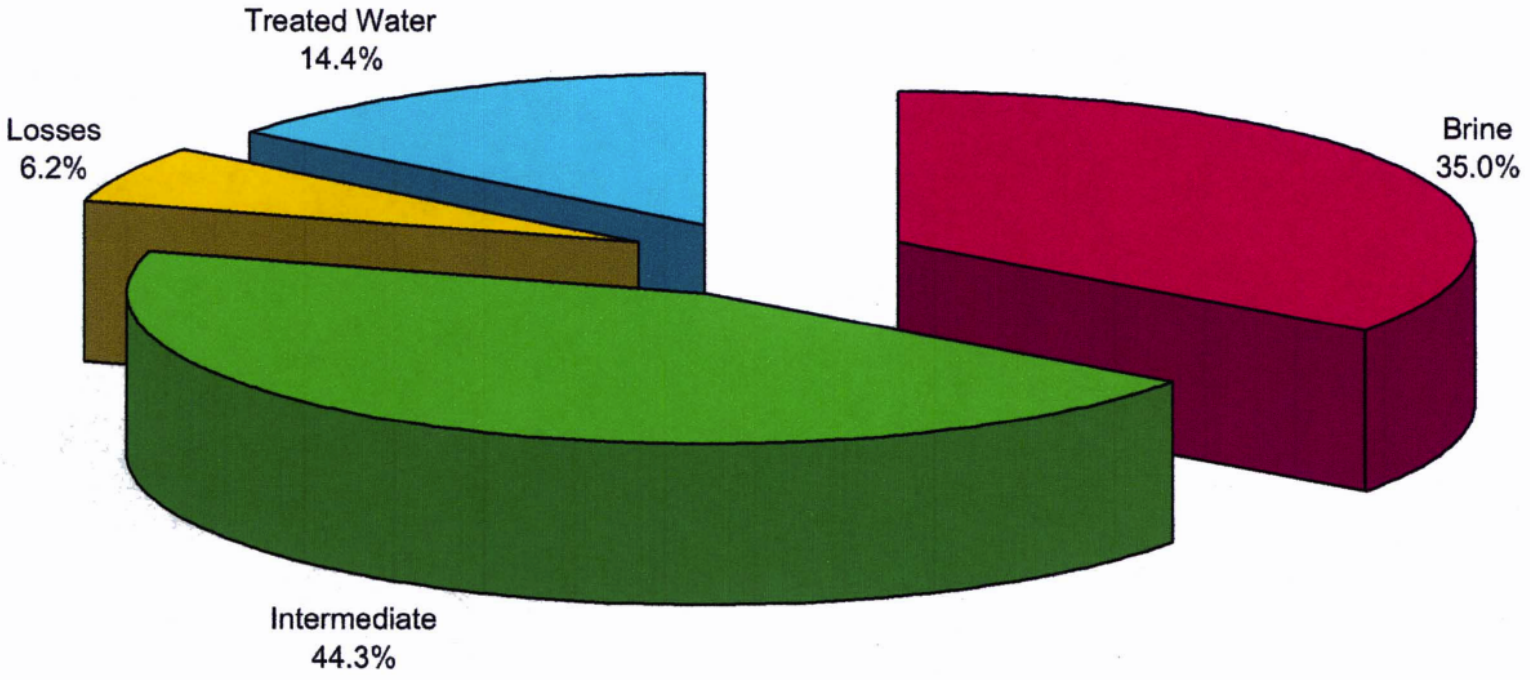


Figure A-3. FT Simulation Product TDS Yields



APPENDIX B

FINAL ENVIRONMENTAL ASSESSMENT/FONSI

United States Department of the Interior

BUREAU OF RECLAMATION
Dakotas Area Office
P.O. Box 1017
Bismarck, North Dakota 58502

IN REPLY REFER TO

DK-500 (Hiemenz)

Dear Interested Party:

The Bureau of Reclamation (Reclamation) has completed a Final Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for the Freeze/Thaw Demonstration Project at Devils Lake, North Dakota. On October 29, 1998, we distributed a draft of the EA for public review and comment. One action alternative and one no action alternative were evaluated in the EA. The proposed action is to construct a demonstration project that would desalinize water drawn from Devils Lake using a freeze/thaw process. This process allows separation of relatively pure ice crystals from a concentrated brine.

Comments concerning the project have been received and considered. We have decided to issue a FONSI for the proposed alternative, because none of the comments were negative or identified any special environmental issues. The construction of the project, as specified in the FONSI and in accordance with the attendant environmental commitments, will ensure no significant impact on the human or natural environment.

The decision documented in this FONSI is subject to appeal. In order to establish "standing" to qualify for an opportunity to appeal this decision, the appellant must have participated in the decision making process by providing written comments during scoping, in response to the draft EA, or during other public involvement activities. An appeal will be considered valid if the appellant possesses standing and if the appeal is postmarked or facsimile-generated within 5 working days of final publication of the public notice in a newspaper of general circulation. Appeals should be addressed to the Area Manager.

A copy of the Final EA and FONSI for the project is enclosed. Additional copies of the FONSI or the EA may be obtained by writing or calling Greg Hiemenz at 701/250-4242 extension 3611.

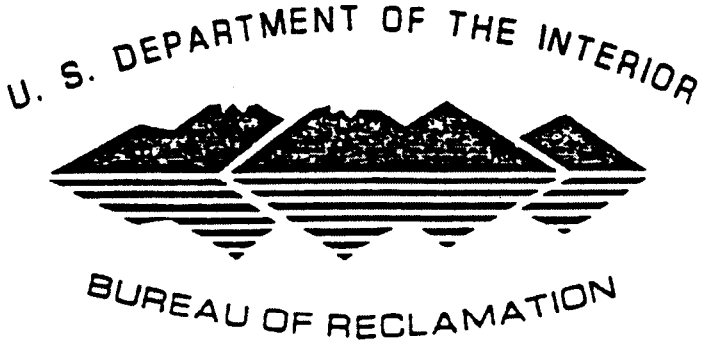
Sincerely,

Dennis E. Breitzman
Area Manager

Enclosure

Final
ENVIRONMENTAL ASSESSMENT

Freeze/Thaw
Demonstration Project
Devils Lake, North Dakota



U.S. Bureau of Reclamation
Dakotas Area Office
Bismarck, North Dakota

DK-600-98-05

DECEMBER 1998

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DAKOTAS AREA OFFICE
BISMARCK, NORTH DAKOTA

FINDING OF NO SIGNIFICANT IMPACT

ENVIRONMENTAL ASSESSMENT FOR THE FREEZE/THAW DEMONSTRATION PROJECT DEVILS LAKE, NORTH DAKOTA

FONSI NO. DK600-98-05

Recommended: Greg Wiesner Date: 8 Dec 98

Preparer
Dakotas Area Office

Concur: [signature] Date: [illegible]

Chief, Resources Management
Dakotas Area Office

Approved: Dennis E. Ruhlman Date: 12/9/98

Area Manager
Dakotas Area Office

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DAKOTAS AREA OFFICE
BISMARCK, NORTH DAKOTA

FINDING OF NO SIGNIFICANT IMPACT

ENVIRONMENTAL ASSESSMENT
FOR THE
FREEZE/THAW DEMONSTRATION PROJECT
DEVILS LAKE, NORTH DAKOTA

FONSI NO. DK600-98-05

Finding of No Significant Impact
Freeze/Thaw Demonstration Project
Devils Lake, North Dakota

Issuance of this Finding of No Significant Impact (FONSI) follows our review of the draft Environmental Assessment (EA) for the Freeze/Thaw Demonstration Project, Devils Lake, North Dakota, and the comments received during the recently-ended public review and comment period.

The purpose of proposed demonstration project is to evaluate the effectiveness of the freeze/thaw process for desalinizing water drawn from Devils Lake, North Dakota. The Bureau of Reclamation is providing funding under its *Research and Technology Transfer Program*, and is the lead Federal agency for compliance with the National Environmental Policy Act (NEPA).

Two alternatives were considered for the project in the EA, DK-600-98-05. The preferred alternative is to construct a freeze/thaw demonstration project covering approximately 10 acres adjacent to Devils Lake. The project site, which has been used as a borrow area for dike construction, is heavily disturbed.

Facilities of the demonstration project would include:

- Six 1-acre ponds to be used for the Freeze/Thaw pad, treated water, brine storage, and feed water holding
- A pump station
- A water pipeline
- A distribution system consisting of control sensors, pumps, and pipelines, to distribute water to the respective ponds
- A building to house personnel and equipment
- An electrical line

Five of the ponds would be lined with poly membrane, the sixth lined with clay. The pump would be a high-vacuum unit to lift water from the lake over an existing dike, or a submersible unit located about 300 to 400 feet out into the lake. The pump intake would be screened to minimize potential impacts to the lake's fishery. The 3-inch diameter pipeline would be approximately 1,000 to 1,500 feet long, including the distance into the lake. The 3-phase electrical power line would be buried along an existing access road to the project site from a nearby Nodak Rural Electric Cooperative transformer.

Planned operation would be to pump approximately 16 million gallons of feed water at a rate of 100 gallons per minute, which would take about 120 days. From the 16 million gallons, it is

anticipated that 15.6 million gallons of freshened water would be recovered, and 400,000 gallons of brine generated. All water would be returned to the lake. Brine would be mixed with treated water before being returned to the lake. Thus, water returned to the lake would have approximately the same concentration of dissolved solids as the source water drawn from the lake. Reclamation has determined that the proposed action as described in the Final EA will not result in significant impacts to the human and natural environment. Therefore, an Environmental Impact Statement will not be prepared. A complete analysis of the project's anticipated environmental impacts is contained in the Final EA.

The reasons for the FONSI determination are summarized as follows:

1. All requirements of the National Environmental Policy Act (NEPA) have been met, including public involvement and coordination with Federal, State, and local agencies.

2. No threatened or endangered species will be adversely affected by the proposed action.

3. All stipulations of the National Historic Preservation Act and other applicable Federal laws, regulations, and guidelines concerning cultural resources will be satisfied.

4. The project area is presently being used as a borrow site, and is already heavily disturbed. Therefore, no significant impacts due to construction activities are anticipated.

5. Water returned to the lake will have approximately the same concentrations of dissolved constituents as the lake water.

6. The project area does not contain Indian Trust Assets (legal interests in property or resources held in trust by the United States for Indian tribes or individuals because of their status as Native Americans).

7. All applicable Federal and State environmental laws, regulations, and executive orders will be adhered to.

The Final EA contains a list of environmental commitments to be implemented in order to (1) prevent, minimize, or offset the occurrence of potential adverse environmental effects and (2) ensure compliance with applicable Federal and State regulations designed to protect fish and wildlife resources, important habitats and sensitive areas, cultural and paleontological resources, human health and safety, and the public interest.

The University of North Dakota will be responsible for complying with any measures required under conditional permits issued by regulatory agencies and/or required by Reclamation. The following commitments, also listed in the Environmental Commitment section of the Final EA, are included as conditions of this FONSI:

- The intake will be screened to decrease the potential for impacts to the Devils Lake fishery.

- The brine and treated water from the freeze/thaw demonstration project will be mixed before returning to the lake, so that the total dissolved solids of the return water will be the same as that of the lake.

- If the project area is not to be used again as a source of fill, it will be recontoured to match the original surface appearance, or to conform to the local area.

- Disposal of pond liners, or any other project equipment, will be done in accordance with applicable State and Federal laws and guidelines.

The decision documented in the EA/FONSI is subject to appeal. In order to have established "standing" to qualify for an opportunity to appeal this decision, the appellant must have participated in the decision making process by providing written comments during scoping, in response to the draft EA, or during public involvement activities. An appeal will be considered valid if the appellant possesses standing and if the appeal is postmarked or facsimile-generated within 5 working days of final publication of the public notice in a newspaper of general circulation. Appeals should be addressed to the Area Manager.

CONTENTS

CHAPTER 1

Introduction

This Draft Environmental Assessment (EA) by the U.S. Bureau of Reclamation analyzes environmental effects of a Freeze/Thaw (FT) Evaporation Demonstration Project at Devils Lake in northern North Dakota (Figure 1.1). The project--which would draw saline water directly from Devils Lake and desalinize it by freezing and thawing--has been proposed for Reclamation's 1999 *Research and Technology Transfer Program* by the University of North Dakota.

The EA complies with NEPA (National Environmental Policy Act). It could lead to a FONSI (*Finding Of No Significant Impact*) if effects are found to be insignificant, or to an EIS (*Environmental Impact Statement*) if found to be significant. Reclamation will make this decision after the public and those interested in the project have a chance to review and comment on the draft EA (see Chapter 4). The FONSI/EIS decision is subject to appeal. To qualify for a chance to appeal, you must provide written comments on the Draft EA (by mail or fax) by the date specified in the letter accompanying the report.

Chapter 1 provides the purpose and need for the project and supplies some background. Chapter 2 describes the alternative plans, and Chapter 3 discusses the environmental effects of the alternatives. The EA concludes with Chapter 4, consultation and coordination with other agencies and the public during preparation of the report.

PURPOSE

The purpose of this project is to demonstrate the potential of using the FT process to treat saline water from Devils Lake. The fresh water thus provided could meet the water needs of the area: M&I (municipal and industrial) water for the Town of Devils Lake, rural water, agriculture, or other water needs. It could also reduce flooding in the area. Any specific plan proposed for use of the water, however, will require a separate NEPA document if it entails a federal action.

Objectives of the project are to:

- Confirm feasibility of the FT process to treat water from Devils Lake
- Provide design criteria for full-scale FT plant to produce M&I water for Devils Lake
- Provide data to aid flood mitigation planning.

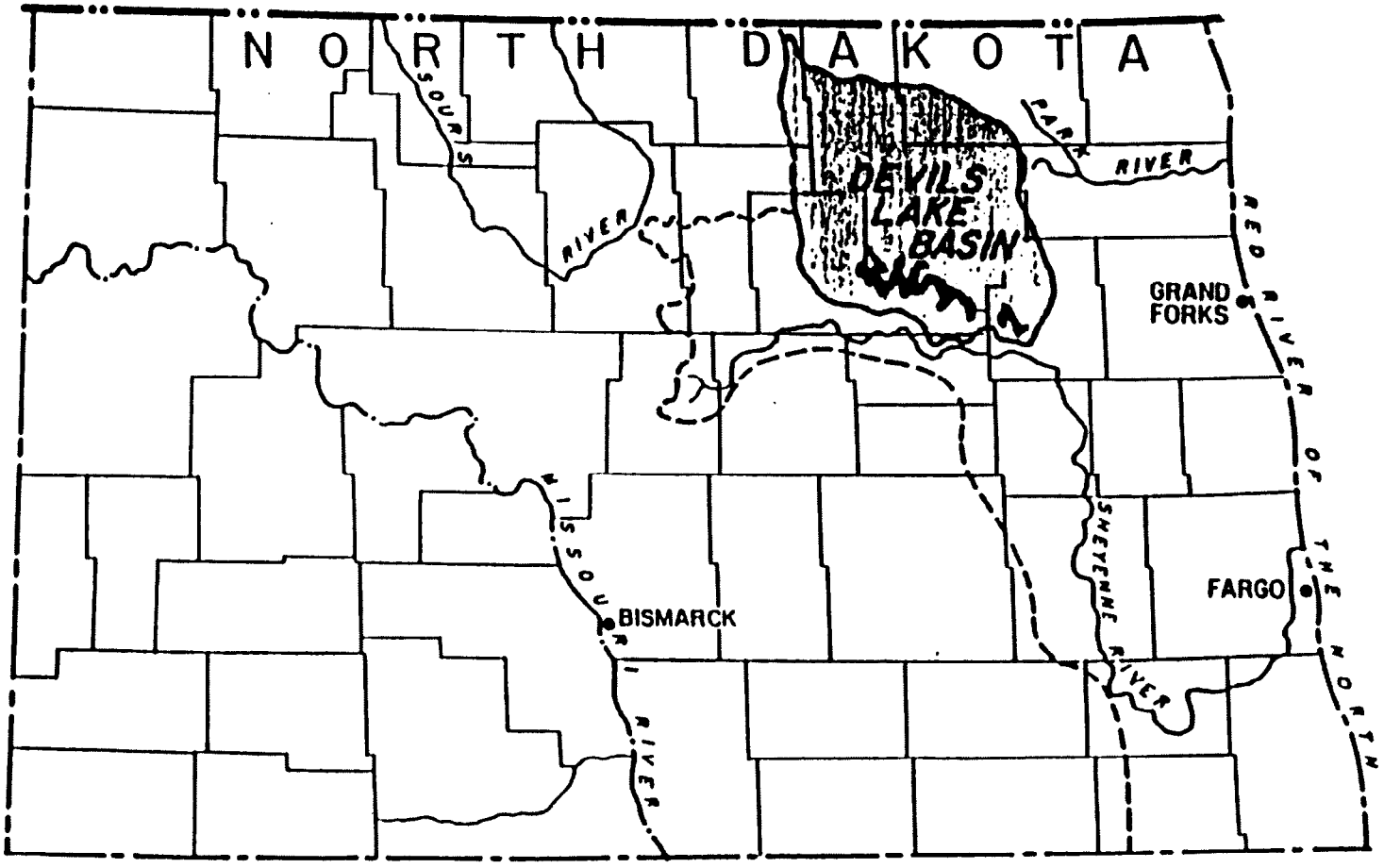


FIGURE 1.1: DEVILS LAKE BASIN

NEED

This project would field test the FT process in North Dakota. Water has been treated by the FT process in other places (most recently in northern New Mexico). but applicability has yet to be demonstrated in North Dakota. Saline water from devils lake is available to meet water needs of the area.

BACKGROUND

The 3,810 sq. Mi. Devils Lake Basin lies in the glaciated plains of north central North Dakota. Glacial thrusting 12,000 years ago produced a broad depression now occupied by the lake. Originally a subbasin of the Red River of the North basin, it is now considered a closed basin (U.S. Army Corps of Engineers, 1988). The basin would have an outlet at a water level elevation of 1459 feet, when it would flow into the Sheyenne River.

The Devils Lake Basin lies between the Turtle Mountains to the northwest and a series of prominent hills to the south. The land surface is rolling plains, with many prairie potholes, sloughs, and occasional ridges formed by glacial moraines.

The area has a humid, continental climate with cool summers (U.S. Bureau of Reclamation, 1988). Temperatures range from -43 ° to 116 ° F. Average annual precipitation is 16.6 inches. Most of the precipitation falls during the 124-day growing season, but blizzards occur occasionally.

The region is a transition zone where tall grasses of the more humid east mingle with short grasses of the western plains (U.S.Bureau of Reclamation, 1988). A gramma and western wheatgrass association grow on the prairies, along with needleandthread, junegrass, and Kentucky bluegrass. Oak and cottonwood grow along streams. Aspen is common in sand dune areas and wolfberry common on rough hillsides.

The area is noted for waterfowl hunting, lying in the Central Flyway, a major flyway for migratory waterfowl as well as for passerine birds. White-tailed deer can be found in the area. Several furbearing wildlife species inhabit the marshes and small streams, and many nongame species can also be found. Devils Lake is also one of North Dakota's premier fisheries, supporting healthy populations of walleye, perch, and northern pike.

Devils Lake is the largest town in the basin, with a 1998 population of 7,958 (Town of Devils lake, 1998). The Fort Totten Reservation, home of the Spirit Lake Sioux Tribe of 6000 people, occupies 59,906 acres south of the town (Devils Lake Sioux Tribe, 1998). The nearest cities are Grand Forks, 100 miles to the east, and Jamestown, 85 miles south. Primary land use in the basin is cultivated agriculture.

CHAPTER 2
Alternatives

Chapter 2 presents the two alternatives analyzed in this EA: The No Action alternative--in which there would be no project. and the Proposed Action. in which a FT (Freeze/Thaw Evaporation) Demonstration Project would be built at Devils Lake. North Dakota. The No Action Alternative Serves as a comparison to determine effects of the proposed action.

No Action Alternative

In this alternative. this FT research would not be conducted. The Devils Lake site would remain a borrow area. None of the FT facilities would be constructed. Information on the FT process in North Dakota would not be obtained from this project.

Proposed Action

The project would demonstrate the potential of using the FT process for treatment of saline water from Devils Lake. Samples of feed water. treated water. and concentrated brine would be collected and analyzed to meet these project objectives:

- determine performance of the demonstration project
- estimate costs associated with a full scale FT plant
- assess the potential of the FT process to contribute to flood mitigation
- at Devils Lake.

Successful demonstration of the FT process under North Dakota climatic conditions could lead to application of the process on a larger scale or in other parts of the region.

The Freeze-Thaw Process

Freezing is a crystallization process that can be used to purify water. When salts or other constituents are dissolved in water. the freezing point of the resultant solution is lowered below 32 degrees F.. the freezing point of pure water. Partial freezing occurs when the solution is cooled to below 32 degrees F.. but not below the freezing point of the solution. Relatively pure ice crystals form. along with an unfrozen solution(or brine) containing high concentrations of the chemical constituents.

Because these constituents have a higher density than that of pure ice, they readily flow from it. Thus, the purified ice can be naturally separated from the brine.

The advantage of natural freezing is that there is no cost for refrigeration and the ice pack can be repeatedly subjected to the FT process. This promotes the formation of large ice crystals, which in turn increase the permeability of the ice pack. An increase in permeability allows the brine to flow more readily through the purified ice pack.

In the FT process, saline feed water is pumped from a holding pond. When the air temperature drops below 32 degrees F, the feed water is sprayed or dripped onto a freezing pad to create a mound of ice. During a thaw, runoff from the mound has high concentrations of chemical constituents. This runoff is diverted into a brine holding pond or back into the feed water pond for recycling, depending on the EC (electrical conductivity--a measure of water quality) of the runoff. When the temperature rises above 32 degrees F, the purified ice melts, and is diverted into a treated water holding pond for later use or discharge. Inexpensive control equipment is used to automatically separate the brine from the purified water, based on the TDS (Total Dissolved Solids) or EC of the water. Figure 2.1 shows a schematic of the process.

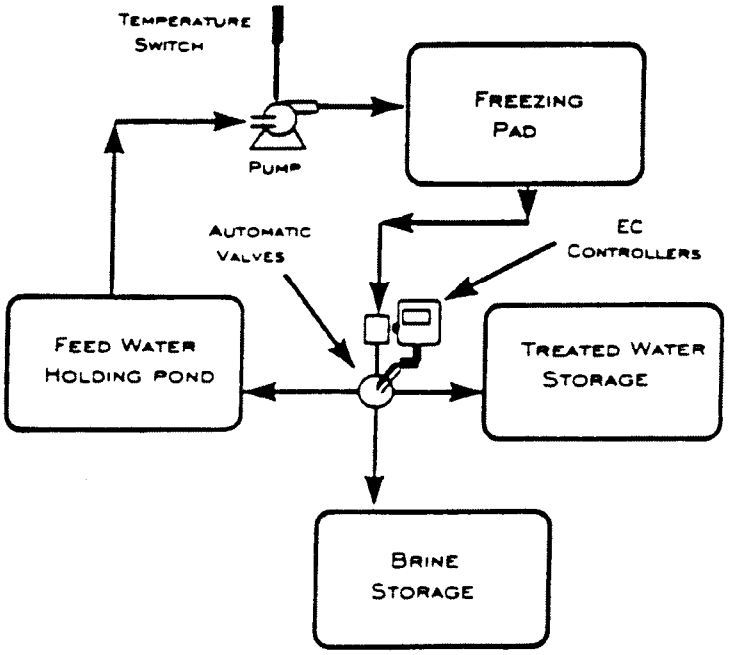


Figure 2.1: Schematic of the FT Process

Successful field tests in northern New Mexico in 1996-1997 proved the capability of the FT process to treat water from coalbed methane production. The Devils Lake Demonstration Project would differ from the New Mexico tests in four ways:

- Climatic conditions in North Dakota are radically different from those in New Mexico.
- TDS of water from Devils Lake is different from that of the New Mexico water.
- The primary goal in New Mexico was wastewater treatment, whereas this project could show the capability of recovering usable water for municipal and industrial supplies.
- The Project would provide information contributing to future flood mitigation planning at Devils lake.

Project Tasks

The demonstration project would proceed by the following tasks:

A. Site selection
B. Simulation testing with Devils Lake water
C. Plant design
d. Acquisition of required site permits
e. Plant construction
f. Plant start-up and shakedown
g. Operation of the plant
h. Site reclamation
I. Plant performance assessment (quarterly reports and a concluding report), economic evaluation, and integration into flood management plans.

Planned Facilities

The Town of Devils Lake has purchased an 80-acre parcel of land bordering Devils Lake on which to locate FT process facilities. This parcel includes the SE¼ of the SE ¼ of Section 5, and the NE ¼ of the NE ¼ of Section 8, both in Township 153 North, Range 64 West, Ramsey County, North Dakota. This land, used as a borrow area for dike construction by the U.S. Army Corps of Engineers (USCOE), is heavily disturbed.

Facilities of the demonstration project would include:

- Six 1-acre ponds to be used for the FT pad, treated water, brine storage, and feed water holding
- A pump station
- A water pipeline
- A distribution system consisting of control sensors, pumps, and pipelines, to distribute different quality water to the respective ponds
- A building to house personnel and equipment
- An electrical line

The 600-foot by 700-foot demonstration project site is heavy clay (having been used by USCOE for lining the dike), so lining of the ponds to prevent leaks is unnecessary (Figure 2.2). Still, five of the ponds would be lined with poly membrane, the sixth lined with clay. This would allow the quality of water from the poly-lined ponds to be compared to the quality from the clay-lined pond.
The pump would be a high vacuum unit to lift water from the lake about 7 feet over the USCOE dike or a screened submersible unit about 300-400 feet out into the lake (Figure 2.2). If the latter, floats would be used to suspend the pump (and pipeline), with a small house erected over it after the lake froze to facilitate maintenance. The pipeline would be 3-inch diameter pipe about 1,000-1,500 feet long (including the distance into the lake). When the lake was frozen, the line would lay on the ice. It would lay on the ground surface from the lake to the demonstration project site for ease of maintenance, being drained between pumping cycles to prevent freezing.

The USCOE has agreed that the pipeline could cross the dike as long as it were covered by 2-foot berm so that it could be driven over without damage.

The 3-phase electrical line to power the pumps and other electrical equipment would be buried along the existing access road to the demonstration project site from a Nodak Rural Electrical Cooperative transformer nearby (Figure 2.2). The dike would protect the site from Devils lake floods.

Planned operation would be to pump approximately 16 million gallons of feed water at a rate of 100 gpm (gallons/minute), which would take about 120 days depending on the number of days freezing temperatures were encountered. From the 16 million gallons, it is anticipated that 15,600,000 gallons of fresh water would be recovered, and 400,000 gallons of brine water generated. Feed water would have an EC of about 1,850 μ s/cm, and the generated brine an EC of about 30,000 μ s/cm.

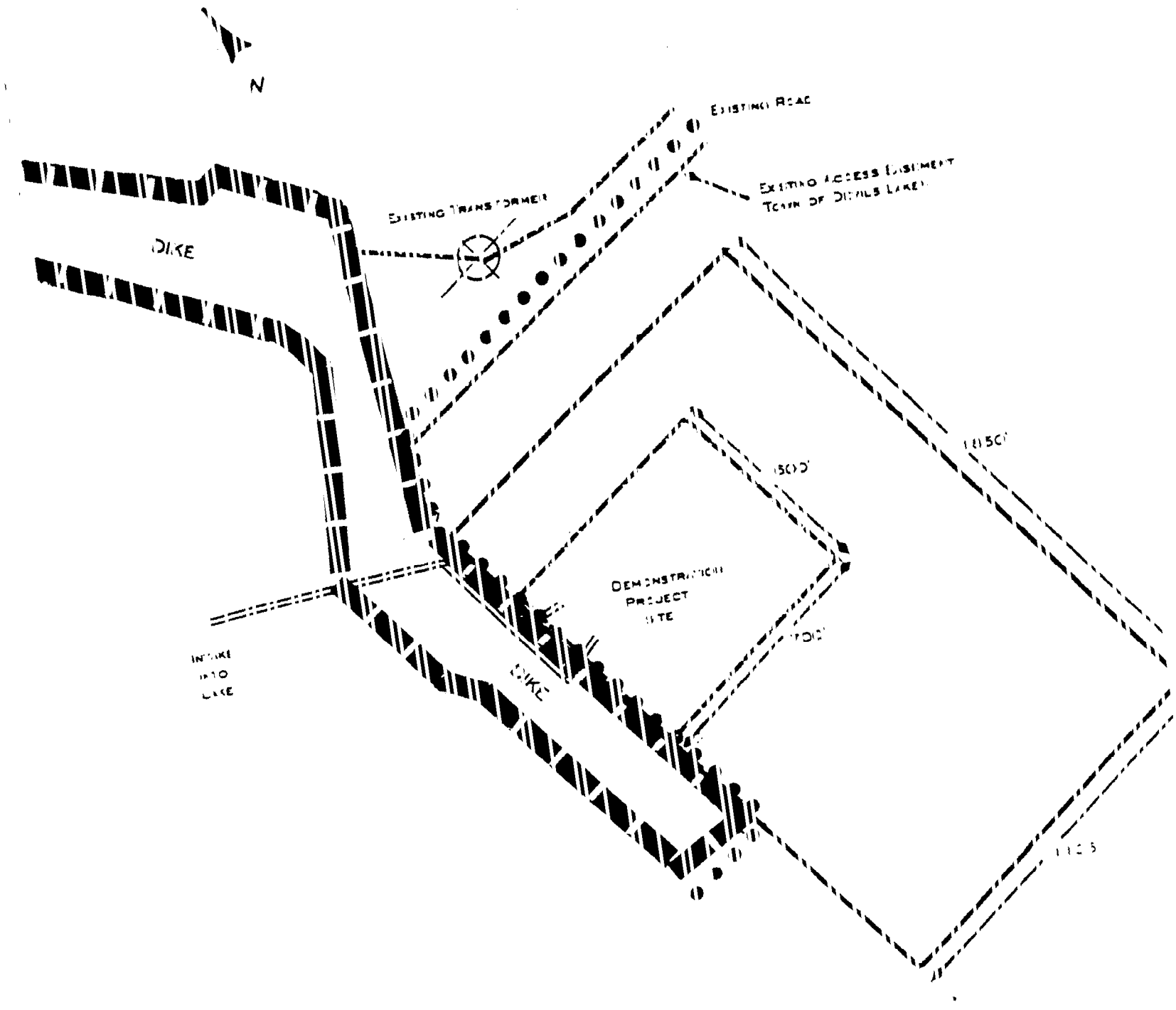


FIG 2.2 DIAGRAM OF DEMONSTRATION PROJECT

The facilities would be operated so that all water would be returned to the lake. Brine generated during the process would be stored and mixed with treated water before being returned. There would be no brine disposal concerns associated with the demonstration project. (In a full scale FT operation where treated water were to be used for a water supply, the issue of brine disposal would have to be addressed.)

Costs and Schedule

Total budget for the demonstration project is estimated to be $954,000, including both construction and operation. The University of North Dakota has requested $400,000 from the North Dakota Office of Intergovernmental Assistance and $250,000 from the North Dakota State Health Department. The remaining $304,000 would be the Bureau of Reclamation's share of the project.

Duration of the project is expected to be 26 months to complete all planned tasks, ending in the fall of 2000. This would encompass two winter seasons.

Site Reclamation

On successful demonstration of the FT process at Devils Lake, the project could be modified into a permanent facility (the 1,135-foot by 1,850-foot area shown in Figure 2.2). In this case, reclamation of the site would not be necessary. Conversion into a permanent facility would, however, require separate NEPA compliance.

In the event of an unsuccessful project or if the project were relocated, the site would be returned to its original condition, unless it was to continue to be used as a borrow area. This would entail removal of all structures, pipelines, pumps, and pond liners. The ponds themselves would be recontoured, covered with the topsoil the USCOE has stored on-site, and revegetated. Pond liners would be disposed of following state and federal environmental regulations.

Required Permits

Because of the wastewater generated by the FT process, Clean Water Act Section 402 and NPDES permits may be required. The project sponsors would obtain these permits if needed.

If any state water rights or diversion permits were required, the project sponsors would obtain them.

A Clean Water Act Section 404 permit should not be needed because no intake is being constructed on the lake shore requiring fill to be placed in the lake.

CHAPTER 3

Affected Environment and Environmental Consequences

This chapter examines the environmental effects of the two alternatives described in Chapter 2. In the No Action Alternative, the Freeze/Thaw (FT) Evaporation Demonstration Project at Devils Lake would not be built. In the Proposed Action, the project would be built and operated.

Because the FT project would be confined to a previously disturbed borrow area (a pit excavated for clay fill), environmental effects would be limited to air quality, water (volume and quality), threatened or endangered species, and cultural resources. These effects are discussed in the pages below, the first part of each section describing the resource, the second part the effects of the alternatives.

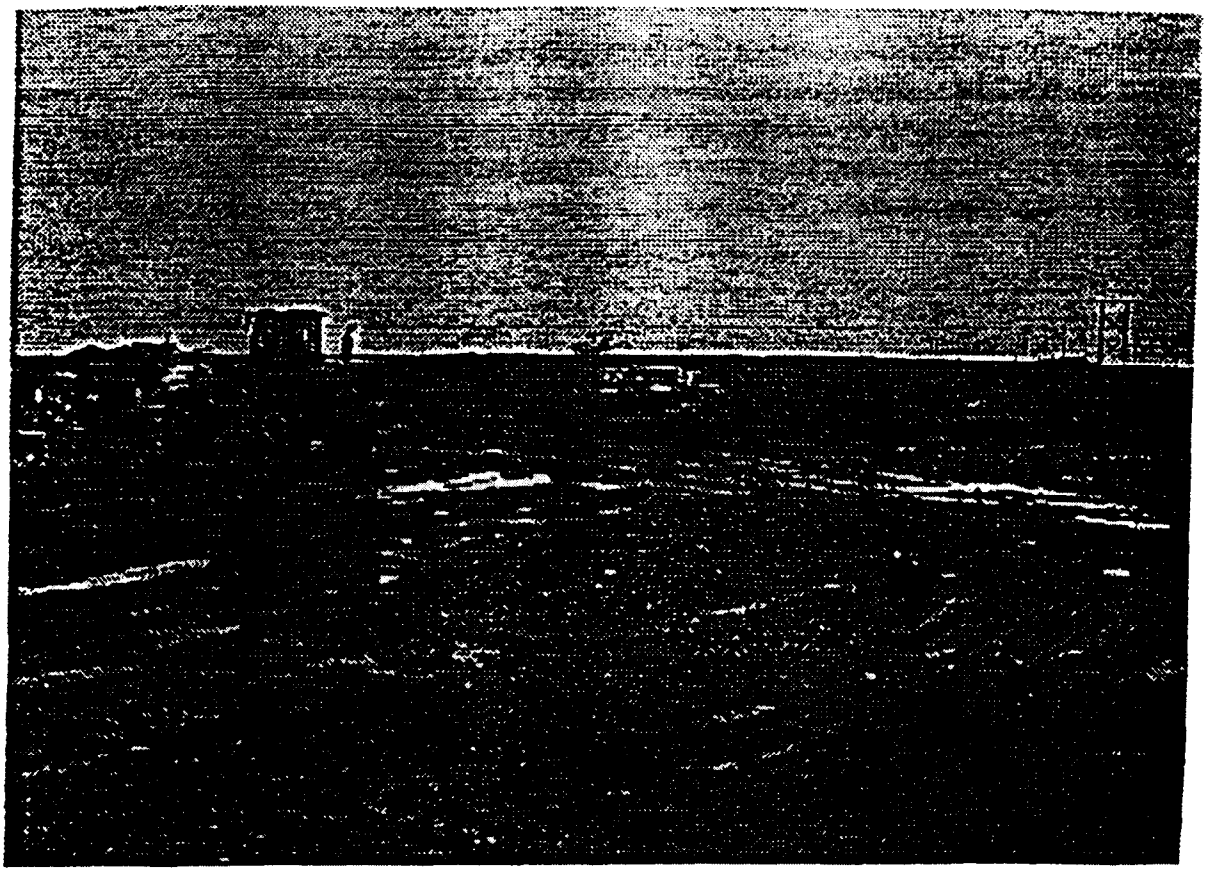


Figure 3.1: Looking NW across the proposed FT project site, showing the disturbed borrow area.

Neither alternative would affect wildlife, fish, or social and economic conditions in the area. Indian Trust Assets--legal interests in property held in trust by the U.S. for tribes--would not be affected since water drawn from Devils Lake would be returned to it. Environmental justice would not be at issue in either alternative.

AIR QUALITY

Air quality is considered good, due to the few industries and homes in the Devils Lake area. Sources of air pollution include farming operations, home heating, traffic on unpaved roads, and wind erosion from roads, fields, pastures, and lake beaches. Particulate concentrations are highest in spring and summer during peak farming activity.

No Action Effects

No FT project would be built in this alternative, so there would be no effect to air quality in the area.

Proposed Action Effects

Six 1-acre ponds would be constructed in this alternative, along with a 1,000-1,500-foot long pipeline from the lake, distribution pipelines, a building, and access roads. This would result in a localized increase in dust and gas and diesel fumes from vehicles involved in the construction. Dust and fumes would be minimized by monitoring construction and by following state and federal air quality regulations.

WATER

Major streams in the area are the Sheyenne and the James Rivers and Pipestem Creek. Basin drainage includes many small streams and lakes, generally flowing from north to south into a chain of five lakes. Most of the water finds its way to Devils Lake, the largest and freshest of a chain of five lakes. For the last 10,000 years, level of the lake has fluctuated between elevation 1,400-1,459 feet. Since 1993, however, the lake has risen to its highest level in 120 years, flooding about 30,000 acres of land and causing highways and road to be closed or rerouted. As of July, 1998, Devils Lake was at elevation 1444.7 feet (U.S. Geological Survey, 1998). The U.S. Army Corps of Engineers is building a dike system that protects the town of Devils Lake to elevation 1,450 feet.

Water quality of Devils Lake can be estimated by looking at TDS (Total Dissolved Solids) concentrations. When a salt--such as sodium chloride (common table salt), for instance--is dissolved in water, the sodium ions and the chloride ions are separated. These ions increase the ability of water to conduct electricity, thus making it possible to estimate TDS concentrations by measuring the electrical conductivity of the water. TDS can be affected by many factors including

geology, topography, and climate. Warm dry periods increase evaporation and concentrate dissolved solids, while wet periods dilute dissolved solids, lowering the concentrations.

Devils Lake consists of several bays which can be isolated from one another. The Lake is characterized by large water level fluctuations and changes in TDS concentrations. TDS generally increases from west to east, as fresher water enters from the west, and is concentrated by evaporation as it moves eastward. Average TDS concentrations during 1988-1990 ranged from 3,400 mg/L (milligrams/per Liter of water) at four sites west of highway 57 to 10,000 mg/L in east Devils Lake. The wet years preceding 1995 dramatically dropped TDS to 1,280-1,880 mg/L.

Dissolved solids concentrations are generally highest in the winter when ice formation concentrates the ions, and lowest in the spring due to the ice melting, surface water inflow, and precipitation. Summer evaporation exceeds inflow and precipitation, also concentrating TDS. Generally, TDS fluctuates inversely with lake levels.

No Action Effects

Neither water volume or water quality would be affected in this alternative.

Proposed Action Effects

The FT project would have a negligible effect on water levels in Devils Lake. It is hoped that information received from the project would be part of an overall flood mitigation plan that could help to reduce future lake levels.

The FT project would be operated so that all water drawn would be returned to the lake. Thus, there would be no net change in TDS in the Lake. Changes due to evaporation would be negligible because of the low evaporation rates in winter when the project would be operated, and the relatively small volume of water being withdrawn. Brine generated by the project would be stored and re-mixed with treated water before being returned to the lake. There would be no brine disposal concerns associated with the project. In a full scale FT facility, where the treated water were to be used, the issue of brine disposal would have to be addressed.

THREATENED OR ENDANGERED SPECIES

As required by the Endangered Species Act, Reclamation consulted with the U.S. Fish and Wildlife Service (USFWS) on threatened or endangered species that could be found in the area of the FT Project. The USFWS identified four species on the threatened or endangered species list that might be in the area. These are:

- peregrine falcon (*Falco peregrinus anatum*)
- whooping crane (*Grus americana*)
- piping plover (*Charadrius melodus*)
- bald eagle (*Haliaeetus leucocephalus*)

Peregrine falcons use almost any habitat providing hunting opportunities, but for nesting purposes they prefer tall cliffs. Prey consists of pigeons, ducks, blackbirds, and other small-medium-sized birds. Most nesting records are from the western half of North Dakota and the Turtle Mountains area. The last record of nesting in North Dakota occurred southwest of Medora in 1954. Today, migrating or transient birds are occasionally reported statewide, with most sightings usually along the Missouri River corridor (USFWS 1998).

Migrating whooping cranes roost on river sandbars and in shallow wetlands that provide good visibility yet have abundant cattails, bulrushes, and sedges. They can also be found feeding in upland areas and agricultural fields during migration, usually within close proximity to nearby wetland and river roost sites. The breeding range at one time included all of North Dakota; the last known breeding record, however, occurred in 1915 in McHenry County. Today, birds are only seen during fall (late-September to mid-October) and spring (late-April to mid-June) migrations, although a young adult summered in the state in 1989, 1990, and 1993 (USFWS 1998). As there are currently about 200 whooping cranes in the wild, sightings are quite rare--only 8 were reported statewide during the fall of 1991. Migrating birds could possibly occur anywhere in North Dakota, but most sightings have been in the western two-thirds of the state (USFWS 1996).

Piping plovers use barren sand and gravel shorelines and sandbars along rivers and lakes, including salt-encrusted beaches surrounding alkaline lakes. The species avoids dense vegetation, instead preferring sparsely vegetated sites 30 yards or more in width. About 15% of the piping plovers in North Dakota use the Missouri and Yellowstone Rivers, while the rest breed in alkaline wetlands (USFWS, 1996). The breeding range of the Great Plains plover population covers parts of seven mid-western states, including much of North Dakota. The species is present in the state only during the late April to August breeding season, after which they migrate to wintering areas along the Gulf of Mexico (USFWS, 1996). In 1991, the state's population was estimated at 472 breeding pairs, with pairs found in 21 of the state's counties. Although the piping plover has been recorded in the Devils Lake basin historically, no recent sightings have been recorded. Surveys of potential plover habitat conducted by the Corps of Engineers and Fish and Wildlife Service in 1986 and 1987 found no piping plovers. Available nesting sites offered only moderate potential based on the physical conditions present. Historical records indicate that suitable habitat may be available during lower water periods.

Wintering bald eagles can be found on unfrozen lakes, rivers, and wetlands in North Dakota. Distribution depends on prey density, suitable perch and roost sites, weather conditions, and freedom from human disturbance (Ohmart and Sell, 1980). Nesting could occur in the Missouri River floodplain forest (USFWS, 1998). Bald eagles were once apparently common along the Missouri and Red Rivers, around Devils Lake, and in the Turtle Mountains (USFWS 1996). As breeding populations declined throughout the continental United States in the 1950's and 1960's, however, the North Dakota population declined as well. Following a 14 year absence of nesting records beginning in 1975, the first active bald eagle nest was documented in 1988 in McLean County. Wintering bald eagles might be found throughout the state, but tend to concentrate along the free-flowing and ice-free reaches of the Missouri River.

No Action Effects

The no Action Alternative would not affect threatened or endangered species.

Proposed Action Effects

Occurrences of the bald eagle, peregrine falcon, piping plover and whooping crane are known to be rare in the project area and, when seen, have usually been limited to migrating or transient individuals. Since the FT project would take place in late fall, winter and early spring, it would not affect Migrating or nesting birds. The F/T Project would have a negligible effect on water levels in Devils Lake. These facts, coupled with the already disturbed nature of the project site, have caused Reclamation to determine there would be no adverse effect to any of the listed species.

If any threatened or endangered species were encountered during construction, consultations with USFWS would be initiated to determine appropriate steps to avoid adverse effects, including stopping construction of the project.

CULTURAL RESOURCES

A Class III cultural resources inventory of the borrow area was done in 1996 by an archeologist for the U.S. Army Corps of engineers. He reported no cultural resource sites. Since then, the area has been used as a source of clay fill.

No Action Effects

This alternative would have no effect on cultural resources.

Proposed Action Effects

Consultation under the National Historic Preservation Act was initiated by letter to the State Historical Society of North Dakota September 17, 1998 (attached at the end of this report). Reclamation has determined that due to the lack of recorded sites in the FT Project area, there would be no impacts to cultural resources. The State concurred with this determination September 21, 1998.

CHAPTER 4

Consultation and Coordination

Chapter 4 describes consultation and coordination with the USFWS, the Spirit Lake Sioux Tribe, and the public that took place during preparation of this report. It concludes with a section on permits required for the Proposed Action.

U.S. FISH AND WILDLIFE SERVICE

Reclamation wrote to USFWS September 9, 1998, about possible threatened or endangered species that could be in the area. The USFWS was also sent a copy of the draft EA (Environmental Assessment) for review and comment.

SPIRIT LAKE SIOUX NATION

Reclamation contacted the Spirit Lake Sioux Nation September 9, 1998, about *Indian Trust Assets* in regard to the FT Project, including lands minerals, hunting and fishing rights, water rights, and instream flows. Reclamation policy requires the agency to protect trust assets and avoid adverse effects whenever possible.

No trust assets were identified. The Spirit Lake Sioux Nation was sent a copy of the draft EA for review and comment.

REVIEW OF THE DRAFT EA

The list below shows government agencies, organizations, and members of the public sent a copy of the Draft EA for review and comment. Responses to comments received on the Draft EA are in Attachment C.

Mr. Charles Gullicks
Program & Project
Development Division
North Dakota Highway Department
608 East Boulevard Avenue
Bismarck ND 58505-0700

Mr. James L. Winters
Bismarck Regulatory Office
U.S. Army Corps of Engineers
1513 South 12th Street
Bismarck ND 58502

Mr. Allyn J. Sapa
Field Supervisor
U.S. Fish and Wildlife Service
1500 Capitol Avenue
Bismarck ND 58501

Mr. Francis Schwindt
North Dakota Health Department
Box 5520
Bismarck ND 58502

Mr. Edward C. Murphy
North Dakota Geological Survey
600 East Boulevard Avenue
Bismarck ND 58505-0840

Mr. Douglas A. Prchal
Director
North Dakota Parks & Recreation
Department
1835 Bismarck Expressway
Bismarck ND 58504

Mr. Scott Hoag
Natural Resource Conservation Service
P.O. Box 1458
Bismarck ND 58502-1458

State Historic Preservation Officer
Attention: Mr. Michael Simonson
State Historical Society of
North Dakota
612 East Boulevard Avenue
Bismarck ND 58505

Mr. Michael G. McKenna
Natural Resources Chief
North Dakota Game and Fish Department
100 North Bismarck Expressway
Bismarck ND 58501-5095

Ms. Cynthia Mala
Executive Director
Indian Affairs Commission
600 East Boulevard Avenue
Bismarck ND 58505-0300

Division Administrator
Department of Transportation
Federal Highway Administration
1471 Interstate Loop
Bismarck ND 58501-0567

Mr. Art Mielke
President
North Dakota Wildlife Federation. Inc.
P.O. Box 7248
Bismarck ND 58502

Mr. Scott Peterson
President
North Dakota Chapter of the Wildlife
Society
P.O. Box 1442
Bismarck ND 58502

Mr. Dave Sprynczynatyk
State Engineer
North Dakota State Water Commission
State Office Building
900 East Boulevard
Bismarck ND 58501

Myra S. Pearson, Chairperson
Spirit Lake Nation
P.O. Box 359
Fort Totten ND 58335

Ramsey County Commissioners
Ramsey County Courthouse
524 4th Ave.
Devils Lake, ND 58301

District Engineer
Department of the Army
Corps of Engineers
1135 U.S. Post Office and Courthouse
St. Paul MN 55101

Richard Shockey
University of North Dakota
Energy & Environmental
Research Center
P.O. Box 9018
Grand Forks, ND 58202-9018

Fred Bott
Commission President
City Hall, 423 6th Street
P.O. Box 1048
Devils Lake, ND 58301-1048

Mr. Ed Steadman
Associate Director for Research
Energy and Environmental
Research Center
15 North 23rd St.
Grand Forks, ND 58203

REFERENCES CITED

Devils Lake Sioux Tribe. 1998. *Devils Lake Sioux Tribe Homepage.* http://www.codetalk.fed.us/sprtlake.html. Fort Totten, North Dakota.

Town of Devils Lake. 1998. *Devils Lake Homepage.* http://www.devils-lake.k12.nd.us/Area/info. Devils Lake, North Dakota.

U.S. Army Corps of Engineers. 1988. *Devils Lake Basin, North Dakota, Integrated Draft Feasibility Report and Environmental Impact Statement.* USDOD, St. Paul. Minnesota.

U.S. Bureau of Reclamation. 1988. *Special Report--Garrison Diversion Unit Indian Studies: Plan Formulation, Fort Totten Indian Reservation Municipal, Rural, and Industrial Water Supply.* USDI, Billings, Montana.

U.S. Geological Survey. 1998. *Lake Levels, Streamflow, and Surface Water Quality in the Devils Lake Area, North Dakota.* http://srvldndbmk.cr.usgs.gov/public /dvlake/dvlake.hydrol/dvlake.hydrol.html1#hrd1. USDI, Bismarck, North Dakota.

Appendix A

Environmental Commitments

1. The intake pump will be screened to decrease the impacts to the Devils Lake fishery.

2. The brine and treated water that result from this demonstration project will be mixed before returning to the Lake, so that the TDS of the return water will be the same as that of the Lake.

3. If the project area is not to be used again as a source of gravel, it should be recontoured to match the original surface appearance, or to conform to the local area.

4. Disposal of pond liners, or any other project equipment, will be done in accordance with applicable State and Federal laws and/or guidelines.

Appendix B

United States Department of the Interior

BUREAU OF RECLAMATION
Dakotas Area Office
P.O. Box 1017
Bismarck, North Dakota 58502

IN REPLY REFER TO:

DK-600 (Snortland): DK-600-98-05-EA SEP 17 1998

NO PROPERTIES. Project area as described contains no recorded historic properties. We recommend no further action to identify such properties. If project design changes these comments are void. 36 CFR 800.4(a)(1)(ii) & (ii)].

9-21-98
Date

IN RESPONSE PLEASE REFERENCE: 98-906

Mr. Mike Simonson
State Historical Society of North Dakota
North Dakota Heritage Center
612 East Boulevard Avenue
Bismarck ND 58505

Subject: Consultation Under the National Historic Preservation Act for a Freeze/Thaw Demonstration Project at Devils Lake in Ramsey County, North Dakota

Dear Mr. Simonson:

Following 36 CFR Part 800.4, the Bureau of Reclamation (Reclamation), Dakotas Area Office, requests your consultation on our determination of effect for the above-referenced undertaking. Reclamation is the land-administering Federal agency and is responsible for compliance with the National Historic Preservation Act (36 CFR Part 800.2[b]). Per 36 CFR Part 800.4, Reclamation has determined that the proposed undertaking has *no historic properties [36 CFR 800.4(d)]* within the area of potential effects.

I. Description and Location of the Undertaking - Reclamation is proposing to construct a freeze/thaw demonstration project as part of the 1999 Research and Technology Transfer Program with the University of North Dakota. The proposed project would desalinate, through a process of freezing and thawing, saline water drawn from Devils Lake. The project would be located in the SE¼SE¼ of section 5, and the NE¼NE¼ of section 8, of T. 153 N., R. 64 W., in Ramsey County. The demonstration project would consist of six 1-acre ponds, a pump station, a water pipeline, a distribution water to the various holding ponds, a building for personnel and equipment, and an electrical line. The demonstration project is expected to last approximately 26 months. If the project proves to be successful, it could be modified into a permanent facility which would require additional NEPA and NHPA compliance. However, if the results are unsuccessful or the project is relocated, this area would be returned to its original condition. A description of the undertaking and specific project dimensions are found in the enclosed correspondence.

98-906-3

II. Methodology Employed for the Identification of Historic Properties - The undertaking area of effect has been surveyed for cultural resources at a Class III level. The results of the survey are contained in the following report:

Ms.7024 Kinney, W. Jeffrey, Three Proposed Borrow Areas for the Devils Lake Levee Raise. A Class III Cultural Resource Inventory Report, 1997 (Proj.# DACW37-96-C-0025)

III. Identification of Historic Properties and Evaluation of Historical Significance - A file search at the State Historical Society revealed that there are no recorded

State Hist... Rec... SEP 18 19... Bismarck, North Dak...

historic properties located within the area of potential effect of this project. The entire project is located within a disturbed area which was used as the borrow source for the construction of a levee to protect the city of Devils Lake from flooding.

IV. Effects Determination - Reclamation has considered the nature of the undertaking and its potential for affecting historic properties (36 CFR Part 800.2[e]) or archaeological resources (43 CFR Part 7.3[a]). Reclamation has determined that this undertaking has no historic properties [36 CFR 800.4(d)] within the area of potential effects.

V. Discovery Clause - If during the course of any activities associated with this undertaking any districts, sites, buildings, structures, or objects not included in this consultation are discovered, activities will cease in the vicinity of the resource. Reclamation shall ensure that the stipulations of 36 CFR Part 800.11 are satisfied before activities in the vicinity of the previously unidentified property resume.

VI. Amendment Clause - This consultation is only for those undertaking areas of effect identified in the enclosed document. If the impact/effects area of the undertaking change during the course of the project, Reclamation will reinitiate consultation under 36 CFR Part 800 and will not allow any land-disturbing activities to proceed before Section 106 of the National Historic Preservation Act is satisfied.

Should you have any questions, please contact the Area Archaeologist, Signe Snortland at (701) 250-4242, extension 3619, or Biological Technician, Ron Melhouse at (701) 250-4242, extension 3614.

Sincerely,

Ronald D Melhouse

for J. Signe Snortland
Area Archaeologist

Enclosure

Appendix C

1

United States Department of the Interior

FISH AND WILDLIFE SERVICE

NOV

MEMORANDUM

To Area Manager Dakotas Area Office Bureau of Reclamation
Bismarck North Dakota

From Field Supervisor North Dakota Field Office
Bismarck North Dakota

Subject Draft Environmental Assessment for the Freeze Thaw Demonstration Project Devils Lake North Dakota

The Fish and Wildlife Service (Service) has reviewed the Draft Environmental Assessment for the Freeze/Thaw Demonstration Project, Devils Lake, North Dakota, and provide the following comments. The purpose of the project is to demonstrate the potential of using the freeze/thaw method to treat Devils Lake water for municipal and industrial water for the city of Devils Lake, rural water, or agricultural purposes.

Based on information provided in the Environmental Assessment (EA), the Service does not have any fish and wildlife concerns relative to the project. The Service concurs with the Bureau of Reclamation determination that the project will have no adverse effects to any threatened or endangered species.

Thank you for the opportunity to review this EA. If you have need further assistance, please contact Bill Pearson at 250-4401.

Your comment is noted.

North Dakota Geological Survey

John P. Bluemle, State Geologist

November 9 1998

Mr Dennis E Breitzman
U S Bureau of Reclamation
P O Box 1017
Bismarck, North Dakota 58502

RE DK 600 (Olson)

Dear Mr Breitzman

I recently reviewed the draft environmental assessment entitled *Freeze/Thaw Demonstration Project Devils Lake North Dakota* The project appears reasonable and I anticipate that the process will work fairly well However, I believe there are several questions that must be addressed before the project proceed to the demonstration phase The high costs of deep well injection, if this method is chosen for brine disposal, may render the freeze/thaw method uneconomical. 2.1

It is likely that deep-well injection in the Dakota Group is not possible in this area due to the relatively fresh water in the Dakota Since Devils Lake is east of the area where the Dakota is exempted, the U S Environmental Protection Agency would have to grant a permit for disposal and costly evaluation would likely be required of the Dakota before a permit would be issued In response to questions on deep-well disposal in this area, we recently looked at two other potential disposal zones, the Minnelusa Formation and Deadwood Fm Winnipeg Group It is impossible to adequately evaluate the potential of these zones for disposal in the Devils Lake area without having cores or electric logs from the area. None of the three horizons (Dakota, Minnelusa, Deadwood Winnipeg) may be sufficiently permeable in this area to sustain a disposal well In addition to this problem, the Minnelusa and Deadwood/Winnipeg rocks are also potential oil producers and would have to be carefully evaluated to insure that disposal in these horizons would not potentially redistribute oil from one area to another (one royalty owner to another) 2.2

If evaporation ponds are considered as a means of controlling the brine I would suggest you contact the North Dakota Oil and Gas Division and discuss with them some of the problems 2.3

600 East Boulevard Avenue • Bismarck, North Dakota 58505-0840 • Phone (701) 328-8000 • Fax (701) 328-8010

2.1 Your comment is noted For this demonstration project, the brine will be mixed with the purified water and returned to the lake.

2.2 This demonstration project is designed to test the effectiveness of the freeze/thaw method for producing relatively purified water The EA does not evaluate impacts associated with brine disposal for a full-scale project Reclamation agrees that brine disposal could be costly, and could result in significant adverse environmental impacts This would be addressed in a separate NEPA document if a full scale project was proposed

2.3 Your comment is noted

they encountered with brine ponds before they stopped permitting them

In addition, what are the projected annual quantities of fresh water that could be generated by a full-scale operation and what are the projected costs per gallon to treat this water? I realize that a demonstration project would refine the answers to these last two questions but there should be reasonable estimates available at this time. I am concerned that the high cost of brine disposal may render this method uneconomical.

2.4

Sincerely,

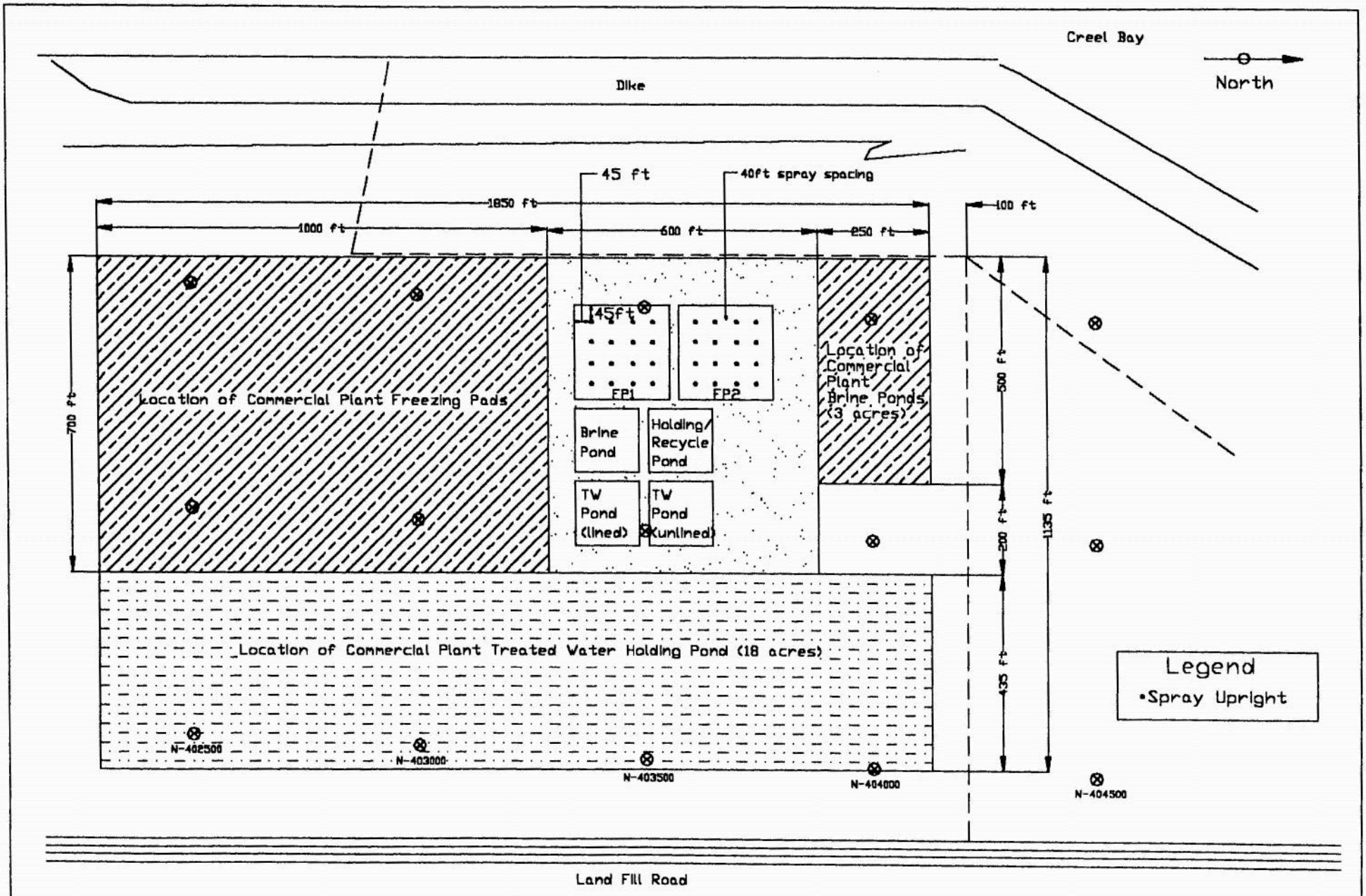
Edward C. Murphy
Geologist

cc: Lynn Helms, ND Oil and Gas Division

2.4 An estimate of the costs associated with a full-scale facility at Devils Lake will be completed as part of this demonstration project. According to a research proposal prepared by the University of North Dakota Energy and Environmental Research Center, preliminary analysis indicates that a 5,000,000 gallon per day facility could be constructed near Grand Forks for approximately $4,000,000. The estimated cost to desalinize water drawn from the Dakota Aquifer and produce potable water was estimated at $0.75/1000 gallons.

APPENDIX C

DESIGN DRAWINGS

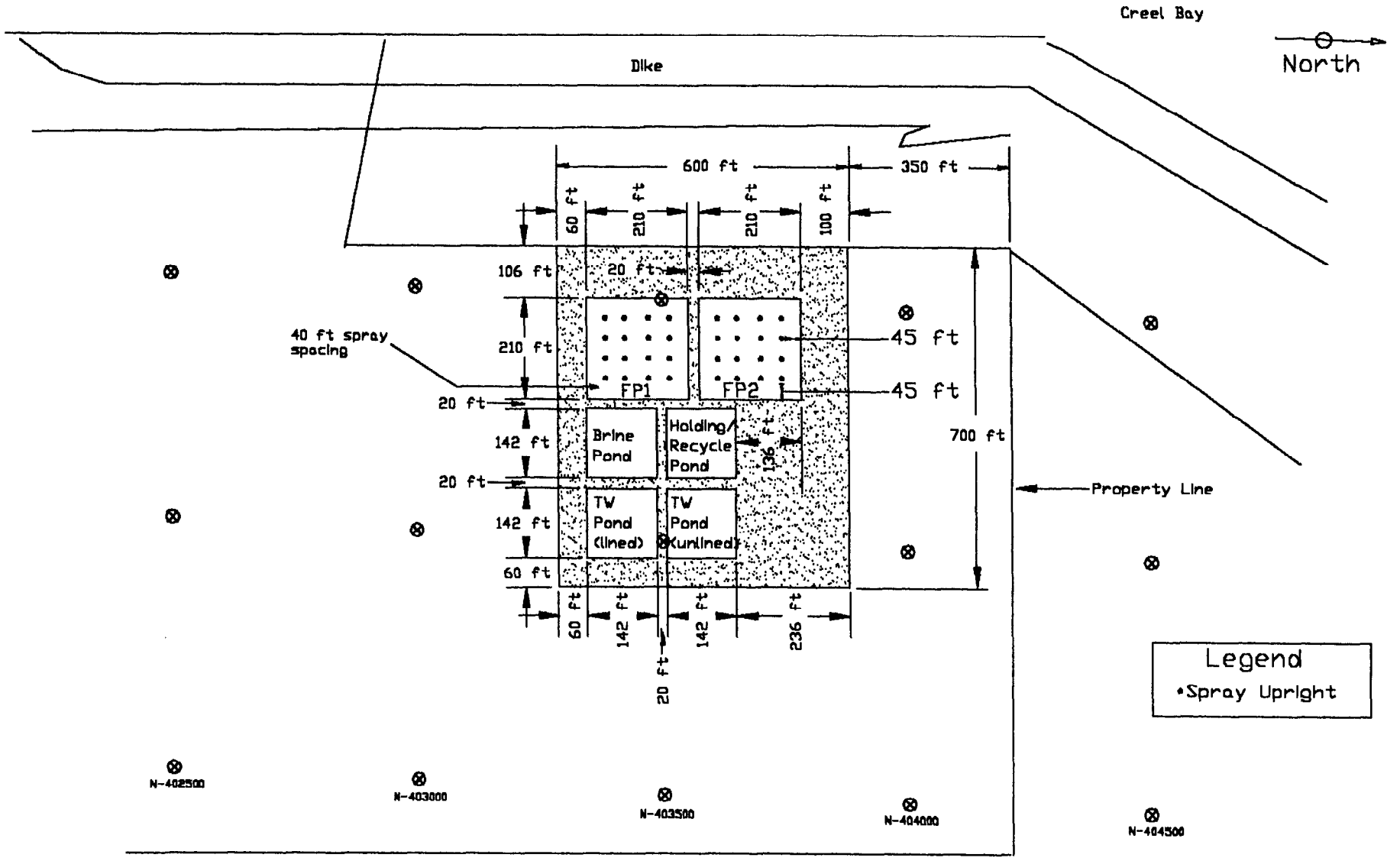


Plan View of Freeze-Thaw Commercial Plant Layout

Commercial facility area is 1135 x 1850ft (42.2 acres).

Additional freezing pads (16 acres)
Brine ponds (3 acres)
Demonstration site (9.6 acres)
Treated water pond (18 acres)

B.C. Technologies, Ltd.			
Drawn by: John Baysen	Devil's Lake Freeze-Thaw Demonstration Site Layout		
Approved: John Baysen	Date: 09/30/98	Scale: No Scale	Drawing No. 1 of 33



Plan View of Freeze-Thaw Demonstration Site Layout

Land required for demonstration site (shaded) is 9.6 acres.

B.C. Technologies, Ltd.			
Drawn by: John Boysen	Devil's Lake Freeze-Thaw Demonstration Site Layout		
Approved: John Boysen	Date: 09/30/98	Scale: No Scale	Drawing No. 2 of 33

APPENDIX D

OPERATING DATA SUMMARIES, DATA DESCRIPTION, AND OPERATOR'S LOG SHEET

FP1 Feed

Start Date	End Date	Operation	To FP1 gal
1/1/99	1/7/99	CB to FP1	899,600
1/12/99	1/14/99	CB to FP1, FP2 rec.	329,329
1/19/99	1/20/99	CB to FP1, FP2 rec.	133,000
1/25/99	1/26/99	Hp to FP1, FP2 rec.	76,965
1/27/99	1/28/99	CB2 to FP1, FP2 rec.	132,700
1/30/99	1/31/99	CB to HP, HP to FP1, FP2 rec	92,385
2/4/99	2/5/99	CB rec, HP to FP1, FP2 rec.	96,400
2/6/99	2/7/99	CB to FP1/rec and HP to FP2	168,691
2/15/99	2/15/99	CB2 to HP and CB1, HP to FP1, FP2 rec.	11,544
2/15/99	2/17/99	CB2 to HP and CB1, HP to FP1, FP2 rec.	105,213
2/23/99	2/24/99	CB2 to HP and CB1, HP to FP1, FP2 rec.	51,890
2/28/99	3/1/99	CB2 to CB1, FP1 to FP1 and FP2	(30,741)
3/2/99	3/3/99	CB2 to CB1, HP to FP1, FP2 rec.	25,294
3/3/99	3/5/99	CB2 to CB1, HP to FP1, FP2 rec.	67,900
3/9/99	3/10/99	CB2 to CB1, HP to FP1, FP2 rec.	39,684
3/10/99	3/11/99	CB2 to FP1 and FP2	21,516
3/13/99	3/13/99	CB2 to CB1 and FP1, FP2 rec.	10,806
3/13/99	3/14/99	CB2 to FP1 and FP2	9,758
3/14/99	3/14/99	CB2 to CB1 , FP1, and FP2	5,414
3/15/99	3/15/99	CB2 to CB1 , FP1, and FP2	3,921
3/15/99	3/15/99	CB2 to CB1 and FP1 , FP2 off	142
4/16/99	4/16/99	HP to FP1 and FP2 (prime)	102
			2,251,513

FP1 Treated Water

Start Date	End Date	Operation	Ec mS/cm	Cal. TDS mg/l	From FP1 gal
3/27/99	3/27/99	CB/HP rec.,FP1 to HP,FP2 to HP	0.30	216	13,299
3/27/99	3/27/99	CB/HP rec.,FP1 to TW,FP2 to HP	0.33	238	20,479
3/27/99	3/27/99	CB/HP rec., FP1 to HP,FP2 to HP	2.30	1659	41,809
3/28/99	3/28/99	CB/HP rec., FP1 to HP,FP2 to HP	2.55	1839	7,784
3/28/99	3/28/99	CB/HP rec., FP1 to BP,FP2 to BP	2.80	2020	9,036
3/30/99	3/31/99	CB/HP rec.,FP1 to HP/rec.,FP2 rec.	1.85	1334	55,430
4/1/99	4/1/99	HP rec., FP1 and FP2 to HP	1.29	931	26,428
4/2/99	4/2/99	HP to CB, FP1 to CB, FP2 rec.	1.52	1096	38,655
4/7/99	4/8/99	HP to CB, FP1 to CB, FP2 rec.	1.50	1082	93,690
4/11/99	4/11/99	HP rec., FP1 to HP, FP2 rec.	0.67	483	67,390
4/11/99	4/11/99	HP rec., FP1 to TW, FP2 rec.	0.50	361	52,487
4/11/99	4/11/99	HP rec., FP1 to HP, FP2 rec.	1.60	1154	14,400
4/12/99	4/12/99	HP rec., FP1 to HP, FP2 rec.	1.68	1212	11,400
4/12/99	4/13/99	HP rec., FP1 to HP, FP2 off	1.00	721	43,032
4/13/99	4/13/99	HP rec., FP1 to HP, FP2 to TW	1.02	736	22,100
4/13/99	4/14/99	HP to BP, FP1 to BP, FP2 to TW	1.02	736	59,160
4/14/99	4/14/99	HP to CB, FP1 to TW, FP2 to TW	0.61	440	8,500
4/14/99	4/14/99	HP to CB, FP1 to TW, FP2 to HP	0.53	382	20,483
4/16/99	4/16/99	HP rec., FP1 to FP1 and FP2	0.76	548	4,547
4/17/99	4/17/99	HP rec., FP1 to TW, FP2 off	0.66	476	41,486
4/18/99	4/18/99	HP rec., FP1 to TW, FP2 off	0.64	462	53,453
4/19/99	4/19/99	HP rec., FP1 to TW, FP2 off	0.57	411	39,011
4/20/99	4/20/99	HP rec., FP1 to TW, FP2 off	0.67	483	58,273
4/21/99	4/21/99	HP rec., FP1 to TW, FP2 off	0.37	267	37,304
4/22/99	4/22/99	HP to CB, FP1 to TW, FP2 off	0.33	238	76,390
4/23/99	4/23/99	HP to CB, FP1 to TW, FP2 off	0.35	252	13,121
4/25/99	4/25/99	HP rec., FP1 to TW, FP2 off, TW to HP	0.25	180	114,992
4/29/99	4/29/99	HP to CB, FP1 to UTW, FP2 off	0.24	173	76,829
4/30/99	4/30/99	HP to CB, FP1 to UTW, FP2 off	0.26	188	159,768
5/1/99	5/1/99	HP rec., FP1 to UTW, FP2 off	0.25	180	88,199
5/3/99	5/3/99	HP rec., FP1 to UTW, FP2 off, TW to HP	0.22	159	63,477
5/3/99	5/3/99	HP rec., FP1 to TW, FP2 off, TW to HP	0.22	159	69,630
5/4/99	5/4/99	HP rec., FP1 to TW, FP2 off, TW to HP	0.17	123	44,127
5/14/99	5/14/99	HP rec., FP1 to HP, FP2 off	0.21	151	46,793
5/15/99	5/15/99	HP rec., FP1 to HP, FP2 off	0.21	151	55,975
5/16/99	5/16/99	HP rec., FP1 to HP, FP2 off	0.20	144	100,125
5/17/99	5/17/99	HP rec., FP1 to HP, FP2 off	0.17	123	78,244
5/23/99	5/23/99	HP rec., FP1 to BP, FP2 off	0.59	426	7,798
5/24/99	5/24/99	HP rec., FP1 to BP, FP2 off	0.48	346	12,689
5/25/99	5/25/99	HP rec., FP1 to BP, FP2 off	0.57	411	19,568
		Total		440.00	1,867,361
				Yield	82.9%

FP1 Intermediated

Start Date	End Date	Operation	Ec mS/cm	Cal. TDS mg/l	From FP1 gal
3/20/99	3/20/99	CB/HP rec, FP1 and FP2 to HP	5.00	3607	36,631
3/21/99	3/21/99	CB/HP rec, FP1 and FP2 to HP	5.00	3607	12,809
3/23/99	3/23/99	CB/HP rec, FP1 and FP2 to HP	3.80	2741	8,627
3/24/99	3/24/99	CB/HP rec, FP1 and FP2 to HP	4.90	3535	39,585
3/25/99	3/25/99	CB/HP rec., FP1 to BP, FP2 to HP	6.00	4328	30,906
		Total		3,700	128,558
				Yield	5.7%

FP1 Brine

Start Date	End Date	Operation	Ec mS/cm	TDS mg/l	From FP1 gal
2/14/99	2/14/99	CB rec., FP1 to BP, FP2 rec.	12.90	10963	47,182
2/23/99	2/23/99	CB2 to CB1, FP1 to BP, FP2 rec.	13.50	11807	14,398
3/9/99	3/9/99	CB2 to CB1, FP1 to BP, FP2 rec.	12.00	9510	13,700
		Total			75,280
				Yield	3.3%

FP2 Feed

Start Date	End Date	Operation	To FP2 gal
1/7/99	1/12/99	CB to FP2, FP1 rec.	1,053,900
1/21/99	1/22/99	CB and FP1 rec., HP to FP2	171,609
1/28/99	1/29/99	CB to HP, FP1 rec., HP to FP2	141,552
2/3/99	2/4/99	CB rec., FP1 rec.,HP to FP2	106,835
2/6/99	2/7/99	CB to HP/rec., FP1 to rec., HP to FP2	82,030
2/6/99	2/7/99	CB to FP1/rec and HP to FP2	79,920
2/13/99	2/14/99	CB and FP1 rec., HP to FP2	160,643
2/21/99	2/21/99	CB2 to CB1, FP1 rec., HP to FP2	11,701
2/21/99	2/21/99	CB to HP, FP1 rec., HP to FP2	10,989
2/21/99	2/22/99	CB2 to HP and CB1, FP1 rec., HP to FP2	121,892
2/28/99	3/1/99	CB2 to CB1, FP1 to FP1 and FP2	30,741
3/8/99	3/8/99	CB1 to CB2, FP1 rec., HP to FP2	6,700
3/8/99	3/8/99	CB1 to CB2, FP1 rec., HP to FP2	21,835
3/10/99	3/11/99	CB2 to FP1 and FP2	63,731
3/13/99	3/14/99	CB2 to FP1 and FP2	25,664
3/14/99	3/14/99	CB2 to CB1 , FP1, and FP2	9,230
3/15/99	3/15/99	CB2 to CB1 , FP1, and FP2	5,294
3/15/99	3/15/99	CB2 to CB1 and FP2, FP1 rec.	4,255
4/15/99	4/15/99	HP to FP1 and FP2 (prime)	30,247
4/16/99	4/16/99	HP to FP1 and FP2 (prime)	4,488
4/16/99	4/16/99	HP rec., FP1 to FP1 and FP2	4,547
		Total Feed to FP2	2,147,803

FP2 Treated Water

Start Date	End Date	Operation	Ec mS/cm	Calculated TDS mg/l	From FP2 gal
4/7/99	4/7/99	HP to CB, FP1 rec., FP2 to CB	1.70	1226	56,440
4/8/99	4/9/99	HP rec., FP1 rec., and FP2 to HP	1.70	1226	132,314
4/9/99	4/9/99	HP to CB,FP1 rec., FP2 to BP	1.65	1190	36,690
4/10/99	4/10/99	HP to CB, FP1 rec.,FP2 to BP	2.00	1443	25,333
4/12/99	4/12/99	HP rec., FP1 rec., FP2 to HP.	1.00	721	85,370
4/12/99	4/12/99	HP rec., FP1 rec., FP2 to HP.	1.00	721	6,178
4/13/99	4/13/99	HP rec., FP1 rec., FP2 to HP.	0.86	620	36,425
4/13/99	4/13/99	HP rec., FP1 rec., FP2 to TW	0.60	433	38,751
4/13/99	4/14/99	HP to BP, FP1 to TP, FP2 to BP	0.86	620	41,175
4/14/99	4/14/99	HP to CB, FP1 rec., FP2 to HP	0.87	628	25,113
4/14/99	4/14/99	HP to CB, FP1 to TW, FP2 to TW	0.82	591	8,953
4/14/99	4/14/99	HP to CB, FP1 to TW, FP2 to HP	0.94	678	4,956
4/17/99	4/17/99	HP rec., FP1 off, FP2 to TW	0.84	606	74,123
4/18/99	4/18/99	HP rec., FP1 off, FP2 to TW	0.70	505	24,564
4/19/99	4/19/99	HP rec., FP1 off, FP2 to TW	0.87	628	41,644
4/20/99	4/20/99	HP rec., FP1 off, FP2 to TW	0.89	642	62,429
4/21/99	4/21/99	HP rec., FP1 off, FP2 to TW	0.61	440	39,445
4/22/99	4/22/99	HP rec., FP1 off, FP2 to TW	0.61	440	6,585
4/22/99	4/22/99	HP to CB, FP1 off, FP2 to TW	0.61	440	53,204
4/23/99	4/23/99	HP to CB, FP1 off, FP2 to HP	0.61	440	547
4/24/99	4/24/99	HP rec., FP1 off, FP2 to TW, TW to HP	0.43	310	98,147
4/26/99	4/26/99	HP rec., FP1 off, FP2 to TW	0.35	252	4,906
4/26/99	4/26/99	HP rec., FP1 off, FP2 to TW, BP to HP	0.35	252	44,124
4/26/99	4/26/99	HP rec., FP1 off, FP2 to TW, BP off	0.35	252	75,470
4/28/99	4/28/99	HP to CB, FP1 off, FP2 to UTW	0.30	216	46,838
4/29/99	4/29/99	HP to CB, FP1 off, FP2 to UTW	0.28	202	75,493
5/2/99	5/2/99	HP rec., FP1 off, FP2 to UTW	0.27	195	16,363
5/2/99	5/2/99	HP rec., FP1 off, FP2 to UTW, TW to HP	0.22	159	122,402
5/5/99	5/5/99	HP rec., FP1 off, FP2 to TW, TW to HP	0.21	151	37,899
5/5/99	5/5/99	HP rec., FP1 off, FP2 to TW, BP to HP	0.21	151	81,367
5/6/99	5/6/99	HP rec., FP1 off, FP2 to TW, BP to HP	0.20	144	40,890
5/6/99	5/6/99	HP rec., FP1 off, FP2 to TW, BP off	0.20	144	25,153
5/7/99	5/7/99	HP rec., FP1 off, FP2 to BP	0.19	137	57,448
5/8/99	5/8/99	HP rec., FP1 off, FP2 to BP	0.17	123	130,128
5/25/99	5/25/99	HP rec., FP1 off, FP2 to BP	0.25	180	24,452
5/26/99	5/26/99	HP rec., FP1 off, FP2 to BP	0.23	166	86,929
5/27/99	5/27/99	HP rec., FP1 off, FP2 to BP	0.41	296	48,681
		Total			1,816,929
				Yield	84.6%

FP2 Intermediate

Start Date	End Date	Operation	Ec mS/cm	Calculated TDS mg/l	From FP2 gal
3/20/99	3/20/99	CB/HP rec, FP1 and FP2 to HP	4.60	3318	24,225
3/21/99	3/21/99	CB/HP rec, FP1 and FP2 to HP	4.15	2994	7,926
3/23/99	3/23/99	CB/HP rec, FP1 and FP2 to HP	3.70	2669	7,776
3/24/99	3/24/99	CB/HP rec, FP1 and FP2 to HP	3.25	2344	32,877
3/25/99	3/25/99	CB/HP rec., FP1 to BP, FP2 to HP	2.80	2020	31,757
3/27/99	3/27/99	CB/HP rec.,FP1 to HP,FP2 to HP	2.70	1948	3,505
3/27/99	3/27/99	CB/HP rec.,FP1 to TW,FP2 to HP	2.30	1659	18,722
3/27/99	3/27/99	CB/HP rec., FP1 to HP,FP2 to HP	2.16	1558	35,604
3/28/99	3/28/99	CB/HP rec., FP1 to HP,FP2 to HP	3.35	2416	5,756
3/28/99	3/28/99	CB/HP rec., FP1 to BP,FP2 to BP	3.50	2525	11,127
3/28/99	3/28/99	CB/HP rec., FP1 rec.,FP2 to BP	2.30	1659	5,170
3/31/99	3/31/99	P1 off.,FP1 to HP/rec.,FP2 to CB	1.77	1277	53,500
4/1/99	4/1/99	HP rec., FP1 and FP2 to HP	1.83	1320	19,576
4/2/99	4/2/99	HP to CB, FP1 rec., FP2 to CB	2.01	1450	50,011
		Total Intermediate			307,532

Dischargable Intermediate

3/27/99	3/27/99	CB/HP rec.,FP1 to TW,FP2 to HP	2.30	1659	18722
3/27/99	3/27/99	CB/HP rec., FP1 to HP,FP2 to HP	2.16	1558	35604
3/28/99	3/28/99	CB/HP rec., FP1 rec.,FP2 to BP	2.30	1659	5170
3/31/99	3/31/99	P1 off.,FP1 to HP/rec.,FP2 to CB	1.77	1277	53500
4/1/99	4/1/99	HP rec., FP1 and FP2 to HP	1.83	1320	19576
4/2/99	4/2/99	HP to CB, FP1 rec., FP2 to CB	2.01	1450	50011
		Total Dischargable Intermediate			182,583
		Total Non-Dischargable Intermediate			124,949

FP2 Brine

Start Date	End Date	Operation	Ec mS/cm	Calculated TDS mg/l	From FP2 gal
2/12/99	2/13/99	CB and FP1 rec., FP2 to BP	14.60	12828	32,044
2/21/99	2/21/99	CB2 to CB1, FP1 rec., FP2 to BP	13.40	11361	16,377
					48,421

Item	Description
Date	Date
Time	Time
Operator Initials	On-site plant operator's initials
Operation	Description of the current operation at the time of the readings
Comments	Operator's comments
F1, gpm	Pump 1 discharge flow rate expressed in gallons per minute.
F1, gal	Pump 1 discharge flow totalizer expressed in gallons.
F2, gpm	Flow rate expressed in gallons per minute delivered to the brine pond.
F2, gal	Cumulative total flow expressed in gallons delivered to the brine pond.
F3, gpm	Flow rate expressed in gallons per minute delivered to the holding pond.
F3, gal	Cumulative total flow expressed in gallons delivered to the holding pond.
F4, gpm	Pump 2 discharge flow rate expressed in gallons per minute.
F4, gal	Pump 2 discharge flow totalizer expressed in gallons.
F5, gpm	Flow rate expressed in gallons per minute delivered to Freeze Pad 1.
F5, gal	Cumulative total flow expressed in gallons delivered to the Freeze Pad 1.
F6, gpm	Flow rate expressed in gallons per minute delivered to the treated water pond.
F6, gal	Cumulative total flow expressed in gallons delivered to the treated water pond.
F7, gpm	Pump 3 discharge flow rate expressed in gallons per minute.
F7, gal	Pump 3 discharge flow totalizer expressed in gallons.
F8, gpm	Flow rate expressed in gallons per minute delivered to Freeze Pad 2.
F8, gal	Cumulative total flow expressed in gallons delivered to the Freeze Pad 2.
TC1, ^{0}F	Temperature of Pump 1 discharge expressed in degrees Fahrenheit.
TC2, ^{0}F	Temperature of Pump 2 discharge expressed in degrees Fahrenheit.
TC3, ^{0}F	Temperature of Pump 3 discharge expressed in degrees Fahrenheit.
TC4, ^{0}F	Temperature of Pump 4 discharge expressed in degrees Fahrenheit.
TC5, ^{0}F	Not used
TC6, ^{0}F	Not used
TC7, ^{0}F	Not used
TC8, ^{0}F	Not used

Item	Description
P1, psi	Pressure at Pump 1 discharge in pounds per square inch.
P2, psi	Pressure at Pump 2 discharge in pounds per square inch.
P3, psi	Pressure at Pump 3 discharge in pounds per square inch.
P4, psi	Pressure at Pump 4 discharge in pounds per square inch.
EC1, mS/cm	Electrical conductivity of the discharge from Pump 1 expressed as milliSeimens per centimeter.
EC2, mS/cm	Electrical conductivity of the discharge from Pump 2 expressed as milliSeimens per centimeter (high level set point).
EC3, mS/cm	Electrical conductivity of the discharge from Pump 2 expressed as milliSeimens per centimeter (low level set point).
EC4, mS/cm	Electrical conductivity of the discharge from Pump 3 expressed as milliSeimens per centimeter (high level set point).
EC5, mS/cm	Electrical conductivity of the discharge from Pump 3 expressed as milliSeimens per centimeter (low level set point).
EC6, mS/cm	Electrical conductivity of the discharge from Pump 4 expressed as milliSeimens per centimeter.
Precipitation, in	Precipitation expressed in inches.
Wind Speed, mph	Wind velocity expressed in miles per hour.
Wind Direction	Wind direction expressed as degrees (0 degrees being north).
Humidity, %	Relative humidity expressed as percent.
Baro Press, atm	Barometric pressure (actually recorded in inches of mercury).
Dew Pt, ^{0}F	Dew point expressed as degrees Fahrenheit.
Solar Flux	Solar radiation expressed as inches per square centimeter.
Ambient Temp, ^{0}F	Ambient air temperature expressed as degrees Fahrenheit.
FP1 Temp, ^{0}F	Temperature at the bottom of Freeze Pad 1 expressed as degrees Fahrenheit.
FP2 Temp, ^{0}F	Temperature at the bottom of Freeze Pad 2 expressed as degrees Fahrenheit.
Ice Temp, ^{0}F	Temperature of ice on Freeze Pad 1 expressed as degrees Fahrenheit.
TP2 Temp, ^{0}F	Not used
BP Temp, ^{0}F	Temperature of the brine pond liquid expressed as degrees Fahrenheit.
HP Temp, ^{0}F	Temperature of the holding pond liquid expressed as degrees Fahrenheit.

PLANT OPERATOR'S LOGSHEET: Page 1

MANUAL READINGS

Date	1/14/99	1/14/99	1/14/99	1/14/99	1/14/99	1/14/99
Time	09:00	11:30	13:45	16:15	17:05	2180
Operator Initials	BJH	BJH	BJH	R.C.Y.	BJH	WB
Operation	CB TO FP1 FP2 RECYCLE	CB2 TO CB1 FP1 RECYC. FP2 RECYC.	NO CHANGE	NO Change	NO CHANGE	NO Change
Comments						
F1, gpm	126	128	131	129	127	131
F1, gal	2727700	2747800	2764300	2784769	2805800	2820557
F2, gpm						
F2, gal						
F3, gpm						
F3, gal						
F4, gpm		153	153	152	154	153
F4, gal		1,255,500	1,274,800	1298689	1323600	1341077
F5, gpm	145	139	140	141	142	151
F5, gal	2342500	2361300	2379300	2401714	2425100	2441589
F6, gpm						
F6, gal						
F7, gpm	168	166	164	168	166	162
F7, gal	415700	441400	462500	488142	515500	534474
F8, gpm	178	183	183	191	184	188
F8, gal	1506900	1535400	1558800	1587322	1617700	1638847
TC1, °F	30.94	30.60	30.92	31.08	31.24	30.85
TC2, °F	53.11	30.61	30.88	30.88	30.76	30.83
TC3, °F	30.82	31.06	31.02	31.20	31.11	31.12
TC4, °F	51.01	51.37	50.56	51.37	48.95	48.70
TC5, °F						
TC6, °F						
TC7, °F						
TC8, °F						

P1, psi	17	19	19	18	20	20
P2, psi	—	~~36~~	35	35	35	35
P3, psi	33	32	32	32	32	32
P4, psi	—	—	—	—	—	—
EC1, mS/cm	2.64	2.63	2.65	2.63	2.66	2.65
EC2, mS/cm	—	~~5.4~~ ~~0.5~~	5.6	4.05	4.33	4.54
EC3, mS/cm	—	~~3.78~~	3.92	5.68	6.0	6.2
EC4, mS/cm	2.4	2.3	2.3	2.7	2.8	2.7
EC5, mS/cm	3.50	3.53	3.49	3.47	3.59	3.67
EC6, mS/cm	—	—	—	—	—	—

DATA LOGGER

Date	1/14/99	1/14/99	1/14/99	1/14/99	1/14/99	1/14/99
Time	09:00	11:30	13:45	16:15	17:05	20:55
Operator Initials	~~BB~~	~~BB~~	~~BB~~	R.C.G.	~~BB~~	WB
Precipitation, in	0.00	0.00	0.00	0.00	0.00	0.00
Wind Speed, MPH	3.6	8.9	11.2	14.8	16.3	27.1
Wind Direction	143	144	~~2~~ 159	143	149	155
Humidity, %	75	78	68	71	73	77
Baro Press, atm	28.48	28.44	28.38	28.28	28.21	28.16
~~Battery~~, VDC DEW PT.	-21.5	-11.4	-7.4	-7.6	-3.6	-0.2
Solar Flux	100	325	295	48	1	1
Ambient Temp, °F	-16.2	-6.9	0.0	-0.9	2.5	4.6
FP1 Temp, °F	31.87	31.79	31.82	31.88	31.83	31.8
FP2 Temp, °F	31.99	31.99	31.98	32.09	32.00	32.00
~~TP1~~ Temp, °F ICE	15.65	17.60	22.66	24.53	26.06	26.50
TP2 Temp, °F	—	—	—	—	—	—
BP Temp, °F	2.88	14.29	19.10	13.05	10.42	12.01
HP Temp, °F	31.38	31.41	31.48	31.54	31.51	31.49

APPENDIX E

METEOROLOGICAL DATA SUMMARY

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
02-Jan-99	20:15	---	---	-10.5	---	---	---	---
02-Jan-99	22:15	---	---	-10.5	---	---	---	---
03-Jan-99	0:20	---	---	-9.8	---	---	---	---
03-Jan-99	2:30	---	---	-7.4	---	---	---	---
03-Jan-99	4:30	---	---	-6.6	---	---	---	---
03-Jan-99	6:30	---	---	-6.6	---	---	---	---
03-Jan-99	8:30	---	---	-12.0	---	---	---	---
03-Jan-99	12:30	---	---	-11.0	---	---	---	---
03-Jan-99	13:25	---	---	-9.6	---	---	---	---
03-Jan-99	15:00	---	---	-9.9	---	---	---	---
03-Jan-99	16:30	---	---	-13.2	---	---	---	---
03-Jan-99	18:00	---	---	-15.9	---	---	---	---
03-Jan-99	20:00	---	---	-18.2	---	---	---	---
03-Jan-99	22:00	---	---	-19.7	---	---	---	---
04-Jan-99	0:00	---	---	-22.1	---	---	---	---
04-Jan-99	2:00	---	---	-23.1	---	---	---	---
04-Jan-99	4:00	---	---	-24.0	---	---	---	---
04-Jan-99	6:00	---	---	-23.6	---	---	---	---
04-Jan-99	8:00	---	---	-23.9	---	---	---	---
04-Jan-99	10:00	---	---	-18.5	---	---	---	---
04-Jan-99	12:00	---	---	-2.0	---	---	---	---
04-Jan-99	14:00	---	---	4.0	---	---	---	---
04-Jan-99	16:30	---	---	-2.1	---	---	---	---
04-Jan-99	18:00	---	---	-3.9	---	---	---	---
04-Jan-99	20:00	---	---	-1.7	---	---	---	---
04-Jan-99	22:00	---	---	0.7	---	---	---	---
05-Jan-99	0:00	---	---	-4.8	---	---	---	---
05-Jan-99	2:00	---	---	-1.4	---	---	---	---
05-Jan-99	4:00	---	---	-0.8	---	---	---	---

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
05-Jan-99	6:00	---	---	1.9	---	---	---	---
05-Jan-99	8:00	---	---	2.7	---	---	---	---
05-Jan-99	10:15	---	---	4.7	---	---	---	---
05-Jan-99	12:45	---	---	7.9	---	---	---	---
05-Jan-99	15:00	---	---	8.8	---	---	---	---
05-Jan-99	17:00	---	---	5.2	---	---	---	---
05-Jan-99	19:00	---	---	4.3	---	---	---	---
05-Jan-99	21:00	---	---	3.0	---	---	---	---
05-Jan-99	23:00	---	---	0.6	---	---	---	---
06-Jan-99	1:20	---	---	-8.2	---	---	---	---
06-Jan-99	4:00	---	---	-17.1	---	---	---	---
06-Jan-99	5:00	---	---	-15.6	---	---	---	---
06-Jan-99	7:00	---	---	-14.3	---	---	---	---
06-Jan-99	9:15	---	---	-17.7	---	---	---	---
06-Jan-99	11:00	---	---	-12.8	---	---	---	---
06-Jan-99	13:05	---	---	-10.6	---	---	---	---
06-Jan-99	15:00	---	---	-10.0	---	---	---	---
06-Jan-99	17:15	---	---	-12.8	---	---	---	---
06-Jan-99	19:00	17.0	274	-16.2	69	28.70	-22.7	1
06-Jan-99	20:00	19.2	277	-15.9	69	28.69	-22.4	1
06-Jan-99	22:00	19.7	271	-16.4	69	28.70	-22.9	1
06-Jan-99	23:00	19.2	268	-16.8	69	28.70	-23.6	1
07-Jan-99	0:00	17.7	270	-17.3	69	28.70	-24.2	1
07-Jan-99	1:00	17.4	259	-17.9	69	28.70	-24.7	1
07-Jan-99	2:00	15.4	271	-18.6	68	28.70	-25.2	1
07-Jan-99	3:00	16.3	272	-18.8	69	28.69	-25.4	1
07-Jan-99	4:00	11.6	248	-19.1	72	28.70	-25.1	1
07-Jan-99	5:00	13.4	254	-18.9	71	28.69	-25.1	1
07-Jan-99	6:00	12.1	244	-19.7	73	28.68	-25.2	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
07-Jan-99	7:00	14.1	251	-19.8	72	28.67	-25.6	1
07-Jan-99	8:00	13.0	237	-20.2	73	28.67	-25.8	1
07-Jan-99	9:00	8.9	237	-20.0	73	28.65	-25.4	15
07-Jan-99	10:00	11.9	244	-17.7	72	28.61	-23.4	120
07-Jan-99	11:00	11.9	250	-14.8	67	28.60	-22.2	233
07-Jan-99	12:00	12.8	248	-12.6	64	28.59	-20.7	343
07-Jan-99	13:00	8.9	234	-10.1	62	28.56	-19.1	172
07-Jan-99	14:00	8.7	233	-8.1	61	28.53	-17.5	201
07-Jan-99	15:00	8.1	256	-8.3	63	28.51	-17.0	186
07-Jan-99	16:00	6.3	248	-8.1	62	28.50	-17.3	113
07-Jan-99	17:00	6.9	218	-8.5	63	28.50	-17.3	12
07-Jan-99	18:00	5.4	213	-8.5	64	28.51	-17.0	1
07-Jan-99	19:00	5.6	249	-7.4	66	28.50	-15.3	1
07-Jan-99	20:00	6.7	257	-6.3	68	28.50	-13.7	1
07-Jan-99	21:00	9.2	257	-5.6	70	28.50	-12.3	1
07-Jan-99	22:00	6.5	269	-4.7	71	28.49	-11.4	1
07-Jan-99	23:00	8.5	268	-4.0	72	28.51	-10.3	1
08-Jan-99	0:00	8.3	279	-3.3	74	28.51	-9.0	1
08-Jan-99	1:00	10.7	296	-3.8	70	28.51	-10.5	1
08-Jan-99	2:00	12.1	304	-4.9	67	28.53	-12.6	1
08-Jan-99	3:00	9.6	293	-7.8	71	28.56	-14.1	1
08-Jan-99	4:00	9.2	295	-11.4	73	28.59	-17.1	1
08-Jan-99	5:00	6.9	306	-14.6	72	28.62	-20.4	1
08-Jan-99	6:00	8.7	285	-15.9	77	28.64	-20.6	1
08-Jan-99	7:00	8.7	289	-17.7	76	28.66	-22.5	1
08-Jan-99	8:00	10.3	285	-17.7	75	28.70	-22.5	1
08-Jan-99	9:00	10.3	291	-18.8	74	28.70	-24.2	18
08-Jan-99	10:00	15.9	293	-17.3	73	28.70	-22.9	119
08-Jan-99	11:00	19.0	292	-15.7	71	28.70	-21.8	229

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
08-Jan-99	12:00	22.1	290	-14.6	69	28.70	-21.3	313
08-Jan-99	13:00	22.8	289	-14.1	70	28.69	-20.7	326
08-Jan-99	14:00	22.1	291	-13.4	68	28.68	-20.4	293
08-Jan-99	15:00	23.9	287	-13.4	70	28.67	-19.8	220
08-Jan-99	16:00	24.4	288	-13.9	69	28.67	-20.4	117
08-Jan-99	17:00	21.5	287	-14.4	71	28.69	-20.7	27
08-Jan-99	18:00	19.2	282	-15.7	73	28.70	-21.3	1
08-Jan-99	19:00	20.4	280	-16.8	74	28.72	-22.0	1
08-Jan-99	20:00	20.1	286	-17.7	73	28.72	-23.4	1
08-Jan-99	21:00	15.9	283	-18.4	73	28.72	-24.0	1
08-Jan-99	22:00	17.7	280	-18.8	74	28.71	-24.2	1
08-Jan-99	23:00	15.9	281	-19.3	73	28.70	-24.7	1
09-Jan-99	0:00	18.6	286	-19.8	72	28.70	-25.6	1
09-Jan-99	1:00	15.4	273	-20.2	73	28.70	-25.8	1
09-Jan-99	2:00	12.1	278	-21.1	73	28.69	-26.7	1
09-Jan-99	3:00	9.8	253	-22.4	72	28.67	-28.1	1
09-Jan-99	4:00	12.1	253	-22.0	72	28.67	-27.9	1
09-Jan-99	5:00	12.5	253	-22.0	72	28.64	-27.8	1
09-Jan-99	6:00	6.0	221	-23.1	72	28.62	-28.8	1
09-Jan-99	7:00	5.4	244	-21.8	72	28.59	-27.4	1
09-Jan-99	8:00	7.8	201	-22.5	72	28.57	-28.3	1
09-Jan-99	9:00	6.3	203	-21.6	72	28.54	-27.4	14
09-Jan-99	10:00	9.2	198	-18.8	72	28.49	-24.5	69
09-Jan-99	11:00	10.7	183	-13.9	70	28.45	-20.4	120
09-Jan-99	12:00	8.7	153	-11.7	69	28.41	-18.6	175
09-Jan-99	13:00	10.7	188	-7.6	70	28.33	-14.3	185
09-Jan-99	14:00	10.7	167	-6.0	71	28.29	-12.6	152
09-Jan-99	15:00	9.6	191	-4.0	73	28.26	-9.8	138
09-Jan-99	16:00	8.9	199	-3.6	76	28.25	-8.7	82

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
09-Jan-99	17:00	8.1	238	-2.2	78	28.26	-6.9	20
09-Jan-99	18:00	19.9	297	-1.5	78	28.29	-6.0	1
09-Jan-99	19:00	18.3	310	-3.3	77	28.32	-8.3	1
09-Jan-99	20:00	13.6	301	-6.9	75	28.37	-12.1	1
09-Jan-99	21:00	20.4	300	-8.0	74	28.39	-13.5	1
09-Jan-99	22:00	19.9	307	-9.4	74	28.43	-14.8	1
09-Jan-99	23:00	16.8	313	-10.7	73	28.46	-16.2	1
10-Jan-99	0:00	15.4	299	-11.2	73	28.48	-16.8	1
10-Jan-99	1:00	17.9	297	-13.2	74	28.50	-18.8	1
10-Jan-99	2:00	15.7	308	-14.8	72	28.53	-20.6	1
10-Jan-99	3:00	17.4	305	-15.7	71	28.55	-21.6	1
10-Jan-99	4:00	16.3	297	-16.1	71	28.58	-22.4	1
10-Jan-99	5:00	16.1	306	-16.1	70	28.59	-22.4	1
10-Jan-99	6:00	14.5	290	-17.7	70	28.59	-23.8	1
10-Jan-99	7:00	14.5	293	-18.9	70	28.61	-25.2	1
10-Jan-99	8:00	14.5	293	-17.7	69	28.62	-24.3	1
10-Jan-99	9:00	12.8	282	-16.6	73	28.64	-22.4	7
10-Jan-99	10:00	16.1	290	-15.2	69	28.64	-22.0	54
10-Jan-99	11:00	16.8	290	-13.9	67	28.64	-21.1	127
10-Jan-99	12:00	19.2	293	-13.4	66	28.62	-20.9	241
10-Jan-99	13:00	20.4	294	-13.4	65	28.59	-21.3	306
10-Jan-99	14:00	16.3	295	-12.6	63	28.56	-21.5	294
10-Jan-99	15:00	17.7	286	-12.1	66	28.53	-19.8	227
10-Jan-99	16:00	14.8	280	-11.2	69	28.53	-18.2	114
10-Jan-99	17:00	13.2	276	-11.9	72	28.51	-17.9	20
10-Jan-99	18:00	11.0	280	-12.1	72	28.51	-18.2	1
10-Jan-99	19:00	8.1	249	-12.6	71	28.48	-18.9	1
10-Jan-99	20:00	8.5	249	-11.7	72	28.47	-17.9	1
10-Jan-99	21:00	10.7	251	-10.5	73	28.43	-16.2	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
10-Jan-99	22:00	9.8	236	-9.6	75	28.40	-14.8	1
10-Jan-99	23:00	8.1	225	-9.0	75	28.38	-14.1	1
11-Jan-99	0:00	5.8	217	-8.1	76	28.35	-13.2	1
11-Jan-99	1:00	6.5	165	-7.8	76	28.31	-12.8	1
11-Jan-99	2:00	6.7	141	-7.6	77	28.27	-12.3	1
11-Jan-99	3:00	9.2	117	-6.9	77	28.23	-11.4	1
11-Jan-99	4:00	11.6	112	-6.2	77	28.20	-10.8	1
11-Jan-99	5:00	11.4	102	-6.2	77	28.19	-10.8	1
11-Jan-99	6:00	13.4	88	-6.2	77	28.17	-10.8	1
11-Jan-99	7:00	14.8	89	-6.0	77	28.16	-10.8	1
11-Jan-99	8:00	16.6	88	-5.6	77	28.14	-10.3	1
11-Jan-99	9:00	19.2	100	-5.1	77	28.11	-9.8	5
11-Jan-99	10:00	17.4	92	-5.1	75	28.12	-10.3	40
11-Jan-99	11:00	19.9	91	-5.4	75	28.13	-10.8	92
11-Jan-99	12:00	17.0	83	-5.8	74	28.14	-11.4	155
11-Jan-99	13:00	18.1	64	-7.1	73	28.14	-12.8	153
11-Jan-99	14:00	18.1	57	-7.6	73	28.15	-13.5	127
11-Jan-99	15:00	16.3	47	-7.8	73	28.16	-13.7	114
11-Jan-99	16:00	16.6	45	-8.0	72	28.18	-14.1	77
11-Jan-99	17:00	16.1	44	-9.6	71	28.22	-15.7	21
11-Jan-99	18:00	14.3	46	-11.7	70	28.27	-18.2	1
11-Jan-99	19:00	13.4	45	-13.2	71	28.29	-19.5	1
11-Jan-99	20:00	12.1	49	-14.6	73	28.30	-20.4	1
11-Jan-99	21:00	12.1	49	-14.8	74	28.31	-20.2	1
11-Jan-99	22:00	11.6	54	-14.8	74	28.32	-20.2	1
11-Jan-99	23:00	10.1	69	-14.1	71	28.35	-20.2	1
12-Jan-99	0:00	9.6	79	-13.5	71	28.35	-19.7	1
12-Jan-99	1:00	9.2	64	-13.2	72	28.36	-19.3	1
12-Jan-99	2:00	10.5	62	-13.2	71	28.36	-19.3	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
12-Jan-99	3:00	10.3	72	-13.0	71	28.35	-19.3	1
12-Jan-99	4:00	15.2	73	-12.8	70	28.35	-19.3	1
12-Jan-99	5:00	14.3	72	-12.8	69	28.38	-19.7	1
12-Jan-99	6:00	15.2	68	-13.7	71	28.39	-20.0	1
12-Jan-99	7:00	12.5	49	-14.1	73	28.44	-19.8	1
12-Jan-99	8:00	12.1	34	-14.1	73	28.50	-19.7	1
12-Jan-99	9:00	13.4	46	-14.8	71	28.53	-20.9	5
12-Jan-99	11:00	9.6	35	-15.5	66	28.57	-23.1	192
12-Jan-99	12:00	8.7	39	-15.0	63	28.58	-23.4	275
12-Jan-99	13:00	10.5	26	-15.0	64	28.60	-23.3	316
12-Jan-99	14:00	14.1	29	-15.5	63	28.60	-24.2	301
12-Jan-99	15:00	11.6	37	-15.9	63	28.61	-24.5	235
12-Jan-99	16:00	9.6	30	-16.8	62	28.64	-25.4	130
12-Jan-99	17:00	6.3	26	-19.5	64	28.68	-27.6	33
12-Jan-99	18:00	6.3	33	-23.1	69	28.72	-29.6	1
12-Jan-99	19:00	4.9	28	-24.9	70	28.76	-31.0	1
12-Jan-99	20:00	5.8	36	-27.0	70	28.77	-33.0	1
12-Jan-99	21:00	6.9	102	-27.2	70	28.76	-33.3	1
12-Jan-99	22:00	9.2	112	-26.7	70	28.76	-33.0	1
12-Jan-99	23:00	11.0	136	-24.7	70	28.76	-31.0	1
13-Jan-99	0:00	10.1	142	-24.0	69	28.76	-30.5	1
13-Jan-99	1:00	14.1	129	-23.3	67	28.73	-30.3	1
13-Jan-99	2:00	13.2	133	-22.7	66	28.73	-30.1	1
13-Jan-99	3:00	17.2	135	-21.6	67	28.72	-28.8	1
13-Jan-99	4:00	22.1	129	-19.7	69	28.67	-26.3	1
13-Jan-99	5:00	20.6	132	-17.7	69	28.64	-24.5	1
13-Jan-99	6:00	22.8	136	-15.2	70	28.60	-21.6	1
13-Jan-99	7:00	24.4	136	-12.6	73	28.56	-18.4	1
13-Jan-99	8:00	24.8	142	-11.0	74	28.57	-16.6	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
13-Jan-99	9:00	23.7	136	-11.2	74	28.57	-16.4	5
13-Jan-99	10:00	27.3	133	-10.5	74	28.56	-15.7	41
13-Jan-99	11:00	31.5	129	-9.4	75	28.54	-14.6	101
13-Jan-99	12:00	30.2	129	-8.1	75	28.52	-13.2	143
13-Jan-99	13:00	32.0	134	-6.5	76	28.48	-11.6	159
13-Jan-99	14:00	34.0	139	-3.6	77	28.47	-8.5	211
13-Jan-99	15:00	31.3	140	-2.7	77	28.47	-7.6	144
13-Jan-99	16:00	28.2	136	-2.6	77	28.47	-7.2	79
13-Jan-99	17:00	25.5	132	-2.7	77	28.49	-7.6	32
13-Jan-99	18:00	21.5	126	-3.3	76	28.51	-8.3	1
13-Jan-99	19:00	19.2	126	-2.7	76	28.53	-7.8	1
13-Jan-99	20:00	16.6	120	-2.4	76	28.55	-7.4	1
13-Jan-99	21:00	9.8	109	-2.2	77	28.56	-7.1	1
13-Jan-99	22:00	5.8	62	-4.7	80	28.57	-8.9	1
13-Jan-99	23:00	6.0	330	-9.0	78	28.59	-13.4	1
14-Jan-99	0:00	3.6	340	-11.4	77	28.59	-16.1	1
14-Jan-99	1:00	4.3	323	-12.6	77	28.59	-17.1	1
14-Jan-99	2:00	5.6	278	-15.0	76	28.60	-19.8	1
14-Jan-99	3:00	5.1	353	-17.3	75	28.61	-22.4	1
14-Jan-99	4:00	5.4	235	-17.5	75	28.60	-22.7	1
14-Jan-99	5:00	4.5	271	-17.9	74	28.59	-23.1	1
14-Jan-99	6:00	4.7	296	-17.3	74	28.58	-22.5	1
14-Jan-99	7:00	4.7	77	-19.7	73	28.56	-25.1	1
14-Jan-99	8:00	5.4	121	-20.6	73	28.56	-26.0	1
14-Jan-99	9:00	4.7	149	-17.9	74	28.52	-23.1	26
14-Jan-99	10:00	4.5	140	-14.4	76	28.48	-19.3	144
14-Jan-99	11:00	9.8	144	-10.7	77	28.46	-15.5	252
14-Jan-99	12:00	12.8	147	-6.3	78	28.44	-11.0	324
14-Jan-99	13:00	16.3	160	-2.6	77	28.42	-7.4	372

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
14-Jan-99	14:00	16.3	155	0.0	71	28.39	-6.7	338
14-Jan-99	15:00	15.9	152	0.1	68	28.35	-7.4	224
14-Jan-99	16:00	18.1	141	0.3	68	28.31	-7.4	125
14-Jan-99	17:00	18.6	143	-0.8	71	28.29	-7.4	31
14-Jan-99	18:00	25.5	142	-0.9	72	28.26	-7.1	1
14-Jan-99	19:00	24.6	155	1.4	73	28.24	-4.7	1
14-Jan-99	20:00	28.6	156	2.8	74	28.20	-2.9	1
14-Jan-99	21:00	28.2	157	4.1	76	28.19	-1.3	1
14-Jan-99	22:00	28.4	159	5.7	79	28.13	1.2	1
14-Jan-99	23:00	25.5	158	5.0	79	28.10	0.7	1
15-Jan-99	0:00	23.7	163	5.2	79	28.08	0.9	1
15-Jan-99	1:00	21.3	164	6.6	81	28.04	2.7	1
15-Jan-99	2:00	19.9	167	8.1	82	27.99	4.3	1
15-Jan-99	3:00	16.3	148	9.5	82	27.96	5.7	1
15-Jan-99	4:00	19.2	154	12.4	82	27.93	8.6	1
15-Jan-99	5:00	19.7	164	14.9	81	27.88	10.9	1
15-Jan-99	6:00	15.2	165	17.2	81	27.85	12.9	1
15-Jan-99	7:00	14.5	174	20.5	79	27.82	15.6	1
15-Jan-99	8:00	17.2	211	24.8	76	27.80	19.0	1
15-Jan-99	9:00	18.1	225	27.1	77	27.78	21.6	6
15-Jan-99	10:00	16.8	229	32.2	74	27.78	25.9	51
15-Jan-99	11:00	17.9	234	35.4	73	27.78	28.8	120
15-Jan-99	12:00	17.7	254	37.0	72	27.78	30.0	159
15-Jan-99	13:00	21.9	262	37.2	73	27.76	30.4	205
15-Jan-99	14:00	21.9	277	36.0	77	27.75	30.4	193
15-Jan-99	15:00	24.4	281	34.9	80	27.75	30.4	150
15-Jan-99	16:00	25.3	280	34.2	82	27.77	30.2	93
15-Jan-99	17:00	26.4	277	33.4	83	27.80	29.8	27
15-Jan-99	18:00	31.1	281	32.4	85	27.80	29.3	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
15-Jan-99	19:00	32.0	287	32.0	85	27.83	29.1	1
15-Jan-99	20:00	28.6	286	32.0	85	27.86	28.9	1
15-Jan-99	21:00	26.6	270	31.8	82	27.88	27.9	1
15-Jan-99	22:00	23.7	266	30.9	80	27.88	26.2	1
15-Jan-99	23:00	30.0	270	30.7	77	27.88	25.2	1
16-Jan-99	0:00	25.3	271	30.0	75	27.89	23.9	1
16-Jan-99	1:00	32.0	277	30.4	71	27.90	22.6	1
16-Jan-99	2:00	27.5	275	29.3	69	27.91	21.2	1
16-Jan-99	3:00	24.8	272	27.7	69	27.91	19.6	1
16-Jan-99	4:00	30.9	268	27.0	69	27.91	19.0	1
16-Jan-99	5:00	32.0	267	25.9	71	27.91	18.3	1
16-Jan-99	6:00	29.1	267	24.8	72	27.91	18.0	1
16-Jan-99	7:00	25.3	267	24.1	72	27.92	17.1	1
16-Jan-99	8:00	22.4	265	23.4	73	27.94	16.7	1
16-Jan-99	9:00	20.6	255	21.9	75	27.96	15.8	10
16-Jan-99	10:00	22.1	262	22.5	74	27.97	16.0	81
16-Jan-99	11:00	25.3	263	23.9	71	27.99	16.2	188
16-Jan-99	12:00	21.0	254	24.8	69	28.00	16.7	279
16-Jan-99	13:00	19.0	252	25.3	70	28.00	17.6	323
16-Jan-99	14:00	20.1	253	26.2	70	28.01	18.3	310
16-Jan-99	15:00	19.7	255	26.4	70	28.01	18.7	244
16-Jan-99	16:00	17.2	251	26.2	72	28.02	19.0	139
16-Jan-99	17:00	15.4	245	25.2	72	28.03	18.1	38
16-Jan-99	18:00	8.5	234	21.9	76	28.03	16.3	1
16-Jan-99	19:00	8.1	225	18.9	81	28.04	14.7	1
16-Jan-99	20:00	6.0	205	17.2	82	28.03	13.5	1
16-Jan-99	21:00	5.8	212	18.9	81	28.04	14.5	1
16-Jan-99	22:00	4.7	99	14.4	85	28.04	11.5	1
16-Jan-99	23:00	5.8	57	13.8	87	28.04	11.5	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
17-Jan-99	0:00	6.3	80	12.6	87	28.05	10.0	1
17-Jan-99	1:00	5.4	33	13.1	88	28.05	10.8	1
17-Jan-99	2:00	4.3	17	13.8	86	28.04	11.1	1
17-Jan-99	3:00	6.9	24	14.9	86	28.02	12.2	1
17-Jan-99	4:00	9.2	16	17.1	84	28.02	13.8	1
17-Jan-99	5:00	10.5	9	18.5	84	28.00	15.3	1
17-Jan-99	6:00	11.0	12	19.0	83	27.99	15.4	1
17-Jan-99	7:00	11.4	18	19.2	82	27.99	15.3	1
17-Jan-99	8:00	8.3	2	20.7	78	28.00	15.6	1
17-Jan-99	9:00	11.9	357	22.8	75	28.02	16.7	2
17-Jan-99	10:00	21.5	344	23.7	90	28.02	21.9	21
17-Jan-99	11:00	19.0	350	22.1	90	28.03	20.3	71
17-Jan-99	12:00	19.7	345	22.5	77	28.05	17.1	140
17-Jan-99	13:00	19.7	335	22.6	76	28.05	16.9	170
17-Jan-99	14:00	18.6	333	23.4	76	28.06	17.4	169
17-Jan-99	15:00	23.9	336	22.3	79	28.07	17.4	131
17-Jan-99	16:00	23.7	335	21.4	81	28.09	17.1	89
17-Jan-99	17:00	22.8	340	21.2	81	28.12	16.9	32
17-Jan-99	18:00	23.3	333	21.0	81	28.15	16.7	2
17-Jan-99	19:00	23.9	327	19.6	81	28.18	15.3	1
17-Jan-99	20:00	25.7	326	17.2	81	28.21	13.3	1
17-Jan-99	21:00	23.7	323	16.5	81	28.23	12.4	1
17-Jan-99	22:00	25.3	323	15.4	81	28.25	11.3	1
17-Jan-99	23:00	20.4	324	14.4	80	28.26	10.0	1
18-Jan-99	0:00	19.2	321	13.5	81	28.27	9.5	1
18-Jan-99	1:00	18.1	326	13.3	81	28.26	9.1	1
18-Jan-99	2:00	17.7	322	11.8	80	28.27	7.7	1
18-Jan-99	3:00	17.4	320	10.9	82	28.27	7.3	1
18-Jan-99	4:00	15.7	303	9.5	83	28.28	6.3	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
18-Jan-99	5:00	15.0	304	10.0	84	28.29	7.0	1
18-Jan-99	6:00	15.0	313	9.9	84	28.29	6.8	1
18-Jan-99	7:00	12.8	318	9.9	85	28.30	7.0	1
18-Jan-99	8:00	12.3	311	9.3	85	28.31	6.4	1
18-Jan-99	9:00	11.0	317	8.4	85	28.31	5.5	8
18-Jan-99	10:00	10.5	318	8.2	84	28.31	5.0	67
18-Jan-99	11:00	14.1	325	8.6	82	28.33	4.8	165
18-Jan-99	12:00	11.2	333	9.0	78	28.33	4.3	275
18-Jan-99	13:00	8.3	335	9.5	77	28.33	4.5	324
18-Jan-99	14:00	12.3	341	9.9	78	28.33	5.0	262
18-Jan-99	15:00	11.2	18	9.1	80	28.31	4.8	169
18-Jan-99	16:00	11.0	3	9.9	79	28.30	5.4	165
18-Jan-99	17:00	8.1	31	9.3	80	28.30	5.0	47
18-Jan-99	18:00	5.8	44	8.6	79	28.31	4.1	4
18-Jan-99	19:00	4.5	103	7.9	81	28.31	4.1	1
18-Jan-99	20:00	5.1	104	7.5	82	28.32	3.9	1
18-Jan-99	21:00	9.6	103	7.7	82	28.32	4.3	1
18-Jan-99	22:00	11.9	109	8.1	80	28.31	3.9	1
18-Jan-99	23:00	12.5	126	8.4	74	28.30	2.5	1
19-Jan-99	0:00	13.4	140	8.4	75	28.32	2.7	1
19-Jan-99	1:00	13.4	137	8.6	75	28.31	3.0	1
19-Jan-99	2:00	14.1	135	8.6	76	28.31	3.0	1
19-Jan-99	3:00	14.3	132	8.6	77	28.30	3.4	1
19-Jan-99	4:00	17.0	121	7.9	77	28.28	2.8	1
19-Jan-99	5:00	17.0	122	7.0	78	28.27	2.1	1
19-Jan-99	6:00	15.4	124	5.7	78	28.27	1.0	1
19-Jan-99	7:00	20.1	124	5.5	79	28.27	1.0	1
19-Jan-99	8:00	19.0	121	5.2	79	28.27	0.7	1
19-Jan-99	9:00	19.7	118	4.3	79	28.26	0.0	11

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
19-Jan-99	10:00	18.6	118	4.3	78	28.27	-0.6	49
19-Jan-99	11:00	20.1	119	4.8	78	28.27	0.1	121
19-Jan-99	12:00	18.3	119	5.9	78	28.26	1.0	158
19-Jan-99	13:00	17.9	126	7.5	75	28.24	1.9	263
19-Jan-99	14:00	13.0	114	7.9	75	28.24	2.5	216
19-Jan-99	15:00	11.0	100	7.9	76	28.24	2.7	160
19-Jan-99	16:00	11.2	108	7.7	77	28.25	2.5	97
19-Jan-99	17:00	8.9	94	7.7	77	28.26	2.5	29
19-Jan-99	18:00	11.0	54	6.8	80	28.28	2.5	1
19-Jan-99	19:00	11.9	49	5.4	80	28.30	1.0	1
19-Jan-99	20:00	12.1	48	3.7	79	28.32	-0.8	1
19-Jan-99	21:00	10.7	41	2.7	81	28.33	-0.9	1
19-Jan-99	22:00	9.2	19	1.9	83	28.35	-1.3	1
19-Jan-99	23:00	12.1	9	1.9	82	28.35	-1.8	1
20-Jan-99	0:00	13.6	9	1.8	79	28.36	-2.6	1
20-Jan-99	1:00	13.9	22	1.6	80	28.37	-2.6	1
20-Jan-99	2:00	11.9	26	1.6	79	28.38	-2.6	1
20-Jan-99	3:00	8.7	28	1.4	79	28.38	-2.7	1
20-Jan-99	4:00	8.3	27	-0.2	80	28.38	-4.4	1
20-Jan-99	5:00	5.4	25	-3.5	81	28.38	-7.1	1
20-Jan-99	6:00	5.4	7	-4.5	81	28.39	-8.1	1
20-Jan-99	7:00	0.0	353	-6.0	80	28.40	-9.8	1
20-Jan-99	8:00	3.4	3	-8.0	80	28.40	-11.9	1
20-Jan-99	9:00	5.4	15	-9.6	79	28.41	-13.7	13
20-Jan-99	10:00	5.8	36	-6.9	77	28.40	-11.7	137
20-Jan-99	11:00	7.4	52	-3.5	73	28.40	-9.4	245
20-Jan-99	12:00	5.1	88	-2.0	72	28.40	-8.5	334
20-Jan-99	13:00	5.1	77	-0.9	73	28.39	-7.1	347
20-Jan-99	14:00	8.1	89	0.3	74	28.38	-5.4	325

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
20-Jan-99	15:00	9.8	93	0.3	76	28.35	-4.9	223
20-Jan-99	16:00	10.1	95	0.7	76	28.33	-4.4	121
20-Jan-99	17:00	7.6	98	0.1	78	28.33	-4.4	31
20-Jan-99	18:00	7.4	99	-0.6	80	28.33	-4.5	3
20-Jan-99	19:00	12.3	116	0.3	80	28.33	-3.8	1
20-Jan-99	20:00	11.9	103	0.0	80	28.31	-4.0	1
20-Jan-99	21:00	12.3	104	0.3	81	28.32	-3.6	1
20-Jan-99	22:00	13.6	115	0.9	81	28.31	-2.9	1
20-Jan-99	23:00	14.1	118	1.8	80	28.30	-2.4	1
21-Jan-99	0:00	14.3	116	2.8	79	28.29	-1.3	1
21-Jan-99	1:00	10.7	105	4.1	80	28.28	0.0	1
21-Jan-99	2:00	8.3	94	4.8	80	28.27	0.7	1
21-Jan-99	3:00	9.2	97	5.7	80	28.28	1.4	1
21-Jan-99	4:00	11.9	98	6.3	80	28.27	2.1	1
21-Jan-99	5:00	13.6	97	6.1	80	28.26	1.8	1
21-Jan-99	6:00	18.3	110	7.0	80	28.23	2.7	1
21-Jan-99	7:00	14.8	106	7.9	80	28.23	3.6	1
21-Jan-99	8:00	14.3	102	8.8	80	28.24	4.5	1
21-Jan-99	9:00	12.8	115	10.2	79	28.25	5.7	5
21-Jan-99	10:00	14.3	118	10.9	79	28.26	6.4	56
21-Jan-99	11:00	15.0	112	11.7	81	28.28	7.7	132
21-Jan-99	12:00	14.8	104	12.9	84	28.28	9.9	166
21-Jan-99	13:00	15.2	95	13.6	84	28.27	10.4	204
21-Jan-99	14:00	15.9	97	14.7	84	28.26	11.5	215
21-Jan-99	15:00	16.6	104	14.9	84	28.28	11.7	152
21-Jan-99	16:00	16.1	98	14.9	84	28.29	11.5	98
21-Jan-99	17:00	17.0	97	14.7	86	28.30	12.0	32
21-Jan-99	18:00	14.5	102	15.3	87	28.34	12.9	1
21-Jan-99	19:00	9.6	91	15.4	88	28.35	13.3	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
21-Jan-99	20:00	8.7	67	15.8	87	28.37	13.3	1
21-Jan-99	21:00	8.7	39	16.0	87	28.38	13.5	1
21-Jan-99	22:00	7.4	39	16.0	88	28.39	13.6	1
21-Jan-99	23:00	7.6	36	16.2	88	28.40	14.0	1
22-Jan-99	0:00	10.3	42	16.7	89	28.41	14.7	1
22-Jan-99	1:00	10.3	54	17.2	88	28.41	15.1	1
22-Jan-99	2:00	9.2	52	17.2	89	28.42	15.3	1
22-Jan-99	3:00	7.6	47	17.1	90	28.43	15.6	1
22-Jan-99	4:00	6.5	37	17.2	89	28.44	15.3	1
22-Jan-99	5:00	8.3	38	17.2	89	28.45	15.3	1
22-Jan-99	6:00	6.9	33	17.2	89	28.46	15.4	1
22-Jan-99	7:00	6.5	12	17.1	88	28.47	14.9	1
22-Jan-99	8:00	7.6	9	17.1	87	28.49	14.5	1
22-Jan-99	9:00	9.4	11	17.1	86	28.49	14.5	6
22-Jan-99	10:00	15.0	357	16.9	86	28.50	14.2	64
22-Jan-99	11:00	14.8	20	16.7	84	28.50	13.5	127
22-Jan-99	12:00	14.5	14	16.9	84	28.50	13.6	173
22-Jan-99	13:00	13.6	0	16.9	84	28.50	13.6	215
22-Jan-99	14:00	13.2	358	16.5	84	28.49	13.1	193
22-Jan-99	15:00	13.4	0	16.0	84	28.50	12.7	140
22-Jan-99	16:00	10.7	1	16.0	84	28.50	12.7	78
22-Jan-99	17:00	11.0	353	15.6	85	28.51	12.7	24
22-Jan-99	18:00	11.0	357	15.1	86	28.51	12.2	1
22-Jan-99	19:00	11.6	355	15.1	86	28.50	12.2	1
22-Jan-99	20:00	12.1	353	14.9	87	28.48	12.4	1
22-Jan-99	21:00	6.9	346	13.8	87	28.48	11.7	1
22-Jan-99	23:00	10.5	7	13.3	87	28.46	11.1	1
23-Jan-99	1:00	7.2	349	13.1	87	28.44	10.6	1
23-Jan-99	3:00	8.5	332	12.7	86	28.44	10.2	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
23-Jan-99	5:00	8.7	321	12.4	87	28.40	9.9	1
23-Jan-99	7:00	5.1	353	11.8	89	28.40	10.0	1
23-Jan-99	9:00	7.2	360	11.5	88	28.38	9.3	8
23-Jan-99	11:00	7.4	343	12.0	85	28.41	9.3	102
23-Jan-99	13:00	8.1	345	11.8	82	28.37	8.1	230
23-Jan-99	15:00	7.2	344	11.1	82	28.35	7.5	159
23-Jan-99	17:00	8.3	339	10.9	83	28.38	7.3	5
23-Jan-99	19:00	10.7	341	10.6	83	28.38	7.3	1
23-Jan-99	21:00	10.2	336	10.2	81	28.43	6.4	1
23-Jan-99	23:00	12.1	325	9.5	82	28.43	5.7	1
24-Jan-99	1:00	14.1	337	9.5	82	28.44	5.7	2
24-Jan-99	3:00	10.5	337	9.5	81	28.48	5.4	1
24-Jan-99	5:00	8.7	331	9.1	80	28.52	5.0	1
24-Jan-99	7:00	9.8	339	7.3	81	28.54	3.2	1
24-Jan-99	9:00	5.1	308	0.7	79	28.57	-3.5	32
24-Jan-99	11:00	8.3	321	3.2	73	28.61	-3.1	271
24-Jan-99	14:00	6.3	315	8.2	71	28.60	1.6	359
24-Jan-99	15:00	5.1	292	9.5	74	28.60	3.6	282
24-Jan-99	17:00	12.1	280	5.5	82	28.61	1.8	14
24-Jan-99	19:00	9.8	279	-2.6	81	28.64	-6.2	1
24-Jan-99	20:56	10.1	276	-4.2	79	28.64	-8.3	1
24-Jan-99	23:00	10.3	280	-7.1	79	28.66	-11.4	1
25-Jan-99	0:55	6.7	246	-9.8	73	28.64	-15.7	2
25-Jan-99	2:56	6.9	220	-11.6	73	28.61	-17.3	1
25-Jan-99	5:13	8.3	216	-8.7	70	28.59	-15.3	2
25-Jan-99	6:58	11.0	207	-8.0	71	28.55	-14.4	1
25-Jan-99	9:15	16.1	226	-3.8	70	28.50	-10.5	132
25-Jan-99	11:00	14.8	239	3.4	69	28.47	-4.0	297
25-Jan-99	13:20	15.2	232	9.5	66	28.46	1.0	352

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
25-Jan-99	15:00	13.2	237	12.0	68	28.46	4.3	231
25-Jan-99	17:00	6.5	223	11.1	70	28.47	3.9	21
25-Jan-99	19:00	6.5	223	9.1	73	28.46	2.7	1
25-Jan-99	20:40	10.3	234	8.8	75	28.48	3.0	1
25-Jan-99	22:58	6.7	242	6.6	77	28.48	1.6	1
26-Jan-99	1:00	7.4	231	5.0	78	28.47	0.3	1
26-Jan-99	3:00	3.8	250	3.4	82	28.52	-0.2	2
26-Jan-99	5:00	0.0	7	-4.5	83	28.50	-7.8	1
26-Jan-99	6:50	0.0	11	-1.7	83	28.50	-4.9	1
26-Jan-99	9:00	3.4	123	-0.6	79	28.52	-4.4	31
26-Jan-99	11:00	8.9	71	10.6	74	28.47	4.8	297
26-Jan-99	13:10	7.6	80	13.6	76	28.43	8.1	141
26-Jan-99	15:00	11.0	72	13.8	78	28.38	9.1	103
26-Jan-99	17:00	14.1	56	13.3	77	28.38	8.1	17
26-Jan-99	19:00	25.3	68	13.6	75	28.36	7.9	1
26-Jan-99	21:00	18.6	56	14.9	78	28.35	9.9	1
26-Jan-99	23:00	13.2	57	14.7	77	28.38	9.5	1
27-Jan-99	0:56	13.4	60	15.4	78	28.37	10.6	1
27-Jan-99	2:00	10.7	38	14.2	79	28.38	9.7	1
27-Jan-99	4:00	9.6	39	13.1	82	28.40	9.5	1
27-Jan-99	7:00	8.1	4	12.4	81	28.43	8.6	1
27-Jan-99	9:00	8.5	12	10.6	80	28.47	6.3	64
27-Jan-99	11:00	9.6	24	11.1	79	28.50	5.9	198
27-Jan-99	13:00	7.6	352	12.0	79	28.50	7.3	247
27-Jan-99	15:00	8.1	349	12.2	78	28.48	7.3	241
27-Jan-99	17:00	6.5	311	11.8	79	28.50	7.3	36
27-Jan-99	19:10	6.5	331	11.1	81	28.53	7.0	1
27-Jan-99	20:55	0.0	349	8.8	84	28.53	5.9	1
27-Jan-99	23:00	4.9	288	10.0	84	28.52	7.0	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
28-Jan-99	1:00	2.9	218	8.8	85	28.52	5.9	1
28-Jan-99	3:05	1.0	244	10.0	84	28.52	6.8	1
28-Jan-99	5:00	5.4	209	11.1	86	28.52	8.6	1
28-Jan-99	7:00	4.5	246	13.1	85	28.51	10.4	1
28-Jan-99	9:00	7.6	208	14.2	82	28.51	10.4	43
28-Jan-99	11:00	10.7	187	19.0	75	28.50	12.9	298
28-Jan-99	13:00	18.6	178	20.1	73	28.47	13.5	410
28-Jan-99	15:00	20.1	189	20.1	76	28.41	14.4	228
28-Jan-99	17:00	15.9	209	19.4	76	28.40	14.0	32
28-Jan-99	19:00	10.0	213	16.3	78	28.40	11.1	1
28-Jan-99	21:03	11.9	210	16.3	74	28.38	10.0	2
28-Jan-99	22:58	13.0	221	17.6	72	28.40	11.1	1
29-Jan-99	1:00	12.3	244	19.4	70	28.44	11.7	1
29-Jan-99	2:58	6.9	237	17.4	73	28.48	11.1	1
29-Jan-99	4:55	5.1	233	14.9	77	28.52	9.9	1
29-Jan-99	7:00	7.8	223	13.3	79	28.55	8.6	1
29-Jan-99	9:00	5.1	191	10.6	80	28.59	6.1	75
29-Jan-99	11:00	0.0	25	23.4	61	28.64	12.2	297
29-Jan-99	13:00	0.0	292	33.3	53	28.63	19.0	370
29-Jan-99	16:00	0.0	179	32.4	51	28.61	16.7	99
29-Jan-99	17:00	0.0	231	27.1	62	28.60	16.7	29
29-Jan-99	19:00	4.5	150	20.8	69	28.59	13.1	1
29-Jan-99	21:00	6.9	171	19.9	68	28.60	11.8	2
29-Jan-99	23:00	5.4	160	16.9	71	28.59	9.7	1
30-Jan-99	1:00	4.0	190	19.6	74	28.59	13.5	1
30-Jan-99	3:00	4.9	164	16.9	81	28.59	12.7	1
30-Jan-99	5:00	4.5	124	13.3	80	28.59	9.5	1
30-Jan-99	7:00	0.0	174	9.3	89	28.59	7.5	1
30-Jan-99	9:00	0.0	69	19.2	71	28.61	12.0	87

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
30-Jan-99	11:00	5.8	202	26.1	64	28.66	16.3	299
30-Jan-99	13:00	8.1	147	27.9	64	28.67	18.1	379
30-Jan-99	15:00	9.6	163	30.6	62	28.65	19.9	240
30-Jan-99	17:00	4.9	155	28.8	65	28.65	19.4	32
30-Jan-99	19:00	6.5	147	19.9	79	28.65	15.1	1
30-Jan-99	20:00	6.7	159	20.8	76	28.66	15.1	1
30-Jan-99	21:00	7.4	181	19.0	79	28.66	14.7	1
30-Jan-99	23:00	6.7	161	19.4	80	28.66	14.7	1
31-Jan-99	1:00	5.6	153	15.4	86	28.64	12.6	1
31-Jan-99	3:00	5.8	147	20.7	83	28.64	17.2	1
31-Jan-99	5:00	11.2	151	21.2	79	28.61	16.3	1
31-Jan-99	7:00	11.2	156	25.5	65	28.59	16.0	1
31-Jan-99	9:00	13.9	135	23.9	65	28.55	15.1	67
31-Jan-99	11:00	11.2	167	29.8	50	28.59	13.6	302
31-Jan-99	13:00	17.9	150	26.6	68	28.53	18.1	266
31-Jan-99	15:00	19.9	144	29.7	65	28.47	19.9	127
31-Jan-99	17:00	14.1	154	28.0	68	28.44	19.4	22
31-Jan-99	21:04	18.6	163	27.1	54	28.35	13.3	1
31-Jan-99	23:00	18.3	157	25.3	58	28.31	12.9	1
01-Feb-99	1:00	16.1	168	25.3	60	28.27	14.2	1
01-Feb-99	3:00	19.5	171	24.4	76	28.22	18.5	1
01-Feb-99	5:00	12.3	165	24.8	84	28.17	21.7	1
01-Feb-99	7:00	19.2	162	25.5	88	28.12	23.2	1
01-Feb-99	9:00	8.9	188	27.1	89	28.14	25.0	28
01-Feb-99	11:00	15.9	208	28.2	86	28.11	25.3	222
01-Feb-99	13:00	15.9	266	29.7	79	28.11	24.4	491
01-Feb-99	15:00	23.0	289	29.7	75	28.11	23.2	225
01-Feb-99	17:00	14.3	292	27.9	76	28.16	21.9	70
01-Feb-99	19:00	17.9	289	23.0	79	28.20	18.9	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
01-Feb-99	21:00	9.6	287	19.9	81	28.21	15.6	1
01-Feb-99	23:00	13.4	249	16.5	78	28.19	11.5	1
02-Feb-99	1:00	10.5	219	14.2	75	28.14	8.6	1
02-Feb-99	3:00	13.6	225	16.9	72	28.08	10.0	1
02-Feb-99	5:00	9.8	234	17.8	74	28.02	11.3	1
02-Feb-99	7:00	14.1	255	22.8	74	27.97	16.5	1
02-Feb-99	9:00	11.4	282	21.7	79	27.97	16.9	65
02-Feb-99	11:00	9.6	283	22.1	81	27.96	17.8	81
02-Feb-99	13:00	13.4	278	23.4	76	27.96	17.4	393
02-Feb-99	15:00	7.2	271	25.2	67	27.91	16.3	249
02-Feb-99	17:00	7.4	223	25.2	72	27.84	18.0	49
02-Feb-99	19:00	4.9	209	20.3	82	27.78	16.3	1
02-Feb-99	21:00	6.9	221	21.9	82	27.70	18.0	1
02-Feb-99	23:00	6.5	230	24.8	78	27.68	19.8	1
03-Feb-99	1:00	6.3	247	27.3	79	27.63	22.6	1
03-Feb-99	3:00	5.1	217	27.3	83	27.61	23.7	1
03-Feb-99	5:00	2.9	287	27.3	91	27.62	26.1	1
03-Feb-99	7:00	5.1	347	21.0	94	27.66	26.6	1
03-Feb-99	9:00	15.9	8	18.7	86	27.78	15.8	57
03-Feb-99	11:00	15.0	349	14.5	77	27.93	9.3	229
03-Feb-99	13:05	19.5	330	10.6	77	28.00	5.7	267
03-Feb-99	15:30	17.0	297	8.2	74	28.10	2.1	161
03-Feb-99	17:15	13.6	300	5.0	78	28.16	0.1	37
03-Feb-99	19:05	21.0	291	1.0	79	28.24	-3.3	1
03-Feb-99	20:15	13.4	296	-2.0	76	28.29	-7.1	1
03-Feb-99	23:00	14.1	314	-5.3	68	28.38	-12.8	1
04-Feb-99	1:00	6.3	296	-8.7	72	28.46	-14.8	1
04-Feb-99	2:40	5.6	253	-10.1	70	28.52	-16.6	1
04-Feb-99	5:00	7.6	239	-12.6	73	28.55	-18.4	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
04-Feb-99	7:00	3.6	257	-14.1	76	28.59	-18.9	1
04-Feb-99	9:00	0.0	70	-11.4	69	28.53	-18.0	145
04-Feb-99	11:00	2.9	191	-5.3	65	28.53	-13.4	213
04-Feb-99	14:45	13.4	133	-0.9	69	28.38	-8.1	219
04-Feb-99	17:00	13.2	134	2.5	68	28.34	-5.3	46
04-Feb-99	19:00	15.4	135	-0.8	70	28.30	-8.0	1
04-Feb-99	21:00	10.7	145	-1.7	75	28.25	-7.2	1
04-Feb-99	23:00	11.0	171	0.7	80	28.22	-3.6	1
05-Feb-99	1:00	8.9	176	3.9	81	28.17	-0.2	1
05-Feb-99	3:00	3.6	62	6.6	80	28.17	2.7	1
05-Feb-99	5:00	0.0	191	7.7	81	28.14	3.7	1
05-Feb-99	7:00	3.8	123	4.8	82	28.17	1.6	1
05-Feb-99	9:00	3.4	223	5.7	82	28.18	2.1	88
05-Feb-99	11:00	8.5	254	19.2	74	28.20	12.7	345
05-Feb-99	14:00	7.4	272	25.3	77	28.21	18.0	365
05-Feb-99	15:00	13.2	298	22.8	74	28.23	16.5	291
05-Feb-99	17:00	14.5	295	16.3	76	28.31	10.8	34
05-Feb-99	19:00	14.3	292	10.0	76	28.35	4.8	1
05-Feb-99	21:00	6.3	308	2.8	78	28.41	-2.2	1
05-Feb-99	23:00	7.6	304	-0.9	76	28.45	-6.2	1
06-Feb-99	1:00	7.4	277	-2.9	81	28.48	-6.9	1
06-Feb-99	3:10	0.0	184	-7.4	80	28.50	-11.2	1
06-Feb-99	5:00	0.0	205	-7.4	82	28.47	-11.2	1
06-Feb-99	6:30	0.0	35	-8.9	79	28.48	-12.8	1
06-Feb-99	7:40	0.0	201	-9.8	79	28.51	-14.1	2
06-Feb-99	9:01	3.4	108	-5.1	77	28.47	-9.9	155
06-Feb-99	10:50	15.2	151	2.1	76	28.40	-3.3	281
06-Feb-99	13:17	15.0	157	8.2	71	28.35	1.2	289
06-Feb-99	15:38	11.0	173	11.8	68	28.27	3.6	151

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
06-Feb-99	17:00	10.7	133	10.2	74	28.24	4.1	34
06-Feb-99	18:10	12.8	162	8.2	77	28.21	3.4	1
06-Feb-99	21:55	5.4	151	6.4	80	28.15	2.5	1
06-Feb-99	23:30	13.0	148	5.5	83	28.08	2.1	1
07-Feb-99	2:00	4.7	138	5.5	85	28.02	2.7	1
07-Feb-99	4:00	4.5	133	9.1	91	27.98	7.7	1
07-Feb-99	6:10	6.5	142	10.6	88	27.94	8.6	1
07-Feb-99	7:30	4.0	185	11.3	88	27.92	9.1	1
07-Feb-99	9:25	6.5	155	13.8	89	27.87	11.8	92
07-Feb-99	11:32	5.4	175	23.7	85	27.88	20.5	298
07-Feb-99	14:18	9.4	216	32.9	66	27.83	23.7	349
07-Feb-99	15:00	8.9	222	34.7	68	27.86	25.7	63
07-Feb-99	16:30	11.0	229	30.9	77	27.84	25.2	1
07-Feb-99	20:55	4.7	222	29.7	76	27.82	23.4	1
07-Feb-99	23:00	5.4	213	29.1	73	27.79	22.5	1
08-Feb-99	1:00	4.7	159	28.2	79	27.78	23.2	1
08-Feb-99	3:00	4.9	212	29.3	81	27.74	25.0	1
08-Feb-99	5:00	11.6	288	32.0	91	27.78	30.4	1
08-Feb-99	7:00	11.4	263	32.5	83	27.81	28.9	1
08-Feb-99	9:15	12.3	265	31.5	79	27.87	26.2	126
08-Feb-99	12:45	16.8	266	32.4	73	27.96	25.3	333
08-Feb-99	15:15	9.8	273	33.4	72	28.00	26.1	249
08-Feb-99	17:15	17.4	277	33.4	70	28.04	25.3	50
08-Feb-99	19:30	27.1	282	27.5	79	28.10	22.6	1
08-Feb-99	21:30	26.8	281	26.1	80	28.14	21.6	1
08-Feb-99	23:30	11.0	292	24.6		28.22	20.8	1
09-Feb-99	1:30	19.2	293	23.5	84	28.25	20.1	1
09-Feb-99	2:05	17.0	310	23.0	85	28.25	19.9	1
09-Feb-99	4:00	15.4	304	23.4	86	28.29	20.3	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
09-Feb-99	6:00	8.7	311	22.5	87	28.34	19.8	1
09-Feb-99	7:40	4.0	249	20.3	87	28.35	18.0	1
09-Feb-99	9:30	6.3	153	21.0	86	28.35	18.3	70
09-Feb-99	11:20	13.2	152	23.7	84	28.35	20.3	348
09-Feb-99	13:30	13.6	134	26.4	79	28.30	21.4	421
09-Feb-99	15:15	16.3	134	28.9	77	28.25	23.4	270
09-Feb-99	17:15	15.9	133	26.1	83	28.20	22.3	29
09-Feb-99	19:15	14.1	122	21.9	87	28.17	19.8	1
09-Feb-99	21:15	12.1	125	22.1	88	28.13	19.8	2
09-Feb-99	23:30	17.2	122	26.4	87	28.03	24.1	1
10-Feb-99	1:40	12.1	129	31.8	79	27.96	26.8	1
10-Feb-99	3:40	11.9	127	32.5	76	27.91	26.2	1
10-Feb-99	5:30	8.3	124	30.6	78	27.87	25.2	1
10-Feb-99	7:35	8.7	157	28.0	82	27.82	24.1	1
10-Feb-99	10:00	13.2	153	32.7	79	27.77	27.7	158
10-Feb-99	12:00	17.9	184	37.2	73	27.81	29.7	411
10-Feb-99	14:00	18.3	264	27.9	87	27.81	25.3	198
10-Feb-99	15:00	17.9	289	24.4	88	27.87	22.1	83
10-Feb-99	19:10	16.0	320	19.9	80	28.01	15.1	1
10-Feb-99	21:00	23.0	307	16.0	89	28.05	14.4	1
10-Feb-99	23:00	23.0	311	15.6	81	28.14	11.5	1
11-Feb-99	1:10	16.8	295	13.1	82	28.20	9.3	3
11-Feb-99	3:30	17.2	307	10.6	77	28.25	5.7	2
11-Feb-99	5:00	12.8	303	10.4	77	28.33	5.4	1
11-Feb-99	7:00	17.0	297	7.7	74	28.40	1.9	1
11-Feb-99	11:00	12.8	308	12.7	76	28.42	6.8	226
11-Feb-99	13:00	24.8	293	13.8	79	28.39	9.1	442
11-Feb-99	15:00	23.3	287	13.1	73	28.36	7.0	318
11-Feb-99	17:00	27.5	290	11.8	69	28.34	4.1	49

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
11-Feb-99	19:15	18.3	296	10.2	71	28.36	3.2	1
11-Feb-99	21:00	15.4	301	8.2	73	28.38	1.6	1
11-Feb-99	22:45	19.9	311	6.8	72	28.41	0.3	1
12-Feb-99	1:00	19.9	310	4.6	73	28.43	-1.7	1
12-Feb-99	3:00	13.6	287	1.6	76	28.47	-3.6	1
12-Feb-99	4:55	18.8	296	1.6	75	28.48	-3.6	1
12-Feb-99	6:55	16.3	287	2.5	74	28.54	-3.5	2
12-Feb-99	10:00	18.6	315	5.9	62	28.65	-4.0	217
12-Feb-99	11:00	13.2	299	6.8	65	28.67	-2.0	356
12-Feb-99	13:30	14.1	287	9.1	69	28.73	1.4	429
12-Feb-99	15:00	10.7	310	13.3	60	28.76	2.3	322
12-Feb-99	17:15	10.0	299	10.0	66	28.80	1.4	42
12-Feb-99	19:10	5.0	235	5.0	75	28.82	-0.6	1
12-Feb-99	20:58	5.6	248	3.7	76	28.80	-1.7	1
12-Feb-99	22:56	0.0	61	-0.2	77	28.78	-5.3	2
13-Feb-99	1:00	2.2	192	0.7	79	28.74	-3.6	2
13-Feb-99	2:59	6.0	148	0.7	76	28.70	-4.5	1
13-Feb-99	3:32	4.0	156	1.6	73	28.69	-4.5	1
13-Feb-99	4:55	6.3	157	6.4	61	28.64	-3.8	1
13-Feb-99	7:05	9.8	166	11.1	59	28.57	0.0	1
13-Feb-99	11:00	12.8	214	20.7	64	28.49	10.8	316
13-Feb-99	13:00	9.4	193	26.2	67	28.44	17.4	339
13-Feb-99	17:00	7.4	207	29.7	72	28.38	22.3	49
13-Feb-99	19:00	14.5	229	30.0	73	28.35	23.0	1
13-Feb-99	21:00	14.5	221	28.8	77	28.31	23.2	1
13-Feb-99	23:00	10.1	236	28.2	77	28.28	22.3	1
14-Feb-99	1:00	7.2	234	25.5	79	28.26	20.7	1
14-Feb-99	3:00	6.7	232	24.4	78	28.25	19.4	1
14-Feb-99	5:00	5.6	241	24.6	75	28.25	18.7	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
14-Feb-99	7:00	7.6	240	23.5	76	28.26	18.0	1
14-Feb-99	10:00	9.6	276	29.3	73	28.28	22.6	252
14-Feb-99	11:00	8.3	303	31.1	75	28.31	25.0	413
14-Feb-99	13:00	11.9	331	32.0	76	28.30	25.7	422
14-Feb-99	15:00	2.2	54	33.6	70	28.28	25.3	220
14-Feb-99	16:45	6.9	11	31.5	77	28.30	25.7	55
14-Feb-99	19:15	7.6	31	26.1	88	28.31	23.5	1
14-Feb-99	21:00	5.4	42	25.2	83	28.32	21.4	1
14-Feb-99	23:00	8.7	35	23.4	82	28.32	19.4	1
15-Feb-99	0:45	10.3	17	20.1	82	28.34	16.3	1
15-Feb-99	2:35	10.5	19	20.1	83	28.34	16.3	1
15-Feb-99	5:00	17.7	21	18.3	81	28.33	14.4	1
15-Feb-99	7:00	17.7	5	17.4	82	28.36	13.8	1
15-Feb-99	9:00	16.8	19	17.6	83	28.40	14.0	44
15-Feb-99	11:15	21.9	22	18.5	83	28.42	15.1	224
15-Feb-99	13:00	14.8	2	18.5	82	28.43	15.1	176
15-Feb-99	15:00	18.8	6	16.9	85	28.41		149
15-Feb-99	17:00	14.5	15	12.4	85	28.52	9.5	9
15-Feb-99	20:00	19.5	352	10.0	82	28.56	6.4	1
15-Feb-99	21:45	12.8	354	8.6	82	28.57	5.0	1
15-Feb-99	23:45	11.0	350	5.9	77	28.57	1.0	1
16-Feb-99	2:05	9.2	339	5.5	77	28.59	0.7	1
16-Feb-99	3:35	10.7	342	3.2	78	28.59	-1.5	1
16-Feb-99	6:30	5.6	14	0.0	78	28.58	-4.7	1
16-Feb-99	7:30	4.7	309	-2.7	79	28.58	-7.1	1
16-Feb-99	9:00	5.1	343	-2.6	75	28.58	-7.6	291
16-Feb-99	11:00	6.3	336	1.9	76	28.57	-2.9	301
16-Feb-99	13:00	6.9	2	8.2	72	28.55	1.8	539
16-Feb-99	15:30	5.8	316	10.6	74	28.53	4.8	231

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
16-Feb-99	17:00	8.9	25	9.5	76	28.53	4.3	74
16-Feb-99	19:00	5.1	21	8.2	79	28.56	3.9	1
16-Feb-99	21:00	4.7	49	6.6	81	28.55	2.8	1
16-Feb-99	23:00	2.9	297	4.6	84	28.53	1.4	1
17-Feb-99	1:00	0.0	22	2.3	84	28.53	-0.6	1
17-Feb-99	3:40	0.0	12	-2.7	82	28.50	-6.2	1
17-Feb-99	5:30	0.0	44	-4.2	82	28.47	-7.8	1
17-Feb-99	7:20	0.0	79	-6.9	81	28.47	-10.5	1
17-Feb-99	9:15	5.1	100	-0.2	80	28.42	-4.4	227
17-Feb-99	11:00	4.5	163	6.6	70	28.42		522
17-Feb-99	13:00	8.7	123	7.5	73	28.38	1.2	417
17-Feb-99	15:00	10.1	115	8.6	66	28.35	0.1	207
17-Feb-99	17:15	9.6	95	7.3	68	28.37	-0.2	29
17-Feb-99	18:05	9.6	92	6.4	65	28.38	-2.4	1
17-Feb-99	21:00	11.2	85	4.8	72	28.41	-2.0	1
17-Feb-99	23:00	8.3	104	3.9	73	28.43	-2.4	1
18-Feb-99	1:00	6.3	78	4.6	71	28.46	-2.4	1
18-Feb-99	3:30	6.9	89	4.1	73	28.46	-2.0	1
18-Feb-99	5:30	7.6	98	3.4	77	28.48	-1.3	1
18-Feb-99	7:15	6.5	75	3.7	76	28.50	-1.3	1
18-Feb-99	9:00	8.5	93	2.1	72	28.52	-4.0	108
18-Feb-99	11:30	10.7	114	6.8	74	28.54	1.0	344
18-Feb-99	13:00	10.3	105	9.3	73	28.54	2.8	432
18-Feb-99	15:00	13.0	112	9.7	73	28.53	3.4	190
18-Feb-99	17:00	10.1	106	10.0	75	28.53	4.5	72
18-Feb-99	19:00	11.4	112	8.2	76	28.53	3.0	1
18-Feb-99	21:00	12.3	114	7.0	71	28.53	0.3	1
18-Feb-99	23:00	11.6	134	7.3	70	28.52	0.3	1
19-Feb-99	1:00	14.1	119	7.3	79	28.50	2.7	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
19-Feb-99	3:00	9.6	134	9.1	78	28.48	4.5	1
19-Feb-99	5:00	12.5	124	10.6	77	28.47	5.7	1
19-Feb-99	7:00	13.4	118	11.1	83	28.47	7.5	1
19-Feb-99	9:00	16.3	116	10.6	82	28.47	6.8	1
19-Feb-99	11:00	11.6	129	13.3	82	28.48	9.3	196
19-Feb-99	13:00	15.2	134	14.7	83	28.48	11.1	241
19-Feb-99	15:00	14.5	120	16.5	84	28.48	13.3	243
19-Feb-99	17:00	12.5	125	16.3	84	28.52	12.9	52
19-Feb-99	19:00	17.9	128	15.1	84	28.56	11.8	1
19-Feb-99	21:40	12.5	135	14.2	85	28.60	11.1	1
19-Feb-99	23:00	11.4	132	14.5	81	28.60	10.4	2
20-Feb-99	1:00	10.1	130	14.9	80	28.63	10.4	1
20-Feb-99	3:00	8.5	124	14.2	85	28.66	11.1	1
20-Feb-99	5:00	11.0	126	13.8	85	28.69	10.8	1
20-Feb-99	7:00	8.7	113	13.3	85	28.71	10.2	1
20-Feb-99	9:00	6.3	140	13.3	83	28.76	9.5	87
20-Feb-99	11:00	7.8	133	16.5	76	28.80	10.9	398
20-Feb-99	12:45	10.7	120	15.8	76	28.83	10.4	350
20-Feb-99	15:00	8.1	153	18.7	70	28.84	11.1	226
20-Feb-99	16:50	8.1	144	19.6	72	28.86	12.9	132
20-Feb-99	19:00	4.5	151	12.4	80	28.87	8.2	1
20-Feb-99	21:00	8.5	156	13.6	83	28.87	10.0	1
21-Feb-99	1:15	8.5	197	15.8	81	28.88	11.7	1
21-Feb-99	3:00	3.6	177	15.1	83	28.86	11.8	1
21-Feb-99	5:00	6.5	144	16.0	86	28.86	13.1	1
21-Feb-99	7:15	5.6	208	16.9	88	28.85	14.7	2
21-Feb-99	9:15	8.3	182	19.9	84	28.83	16.5	76
21-Feb-99	11:00	11.0	193	22.6	81	28.83	18.5	268
21-Feb-99	13:00	12.8	189	26.1	77	28.78	20.5	348

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
21-Feb-99	15:00	11.6	184	25.3	78	28.75	19.9	280
21-Feb-99	17:00	10.3	166	23.5	75	28.70	17.6	37
21-Feb-99	19:00	12.5	156	22.5	84	28.70	18.9	1
21-Feb-99	21:00	13.6	140	22.1	84	28.64	18.7	1
21-Feb-99	23:00	14.1	130	21.7	82	28.61	17.6	1
22-Feb-99	1:00	11.0	128	17.4	81	28.56	13.5	1
22-Feb-99	3:00	10.3	108	16.7	82	28.50	13.1	1
22-Feb-99	5:00	13.2	127	17.2	81	28.47	12.9	1
22-Feb-99	7:00	13.2	131	17.6	79	28.46	13.1	1
22-Feb-99	9:00	17.2	117	18.1	78	28.44	12.9	90
22-Feb-99	11:00	13.6	110	20.1	77	28.44	14.7	258
22-Feb-99	13:00	21.0	134	21.0	83	28.43	17.2	340
22-Feb-99	15:00	15.2	129	21.0	87	28.41	18.7	211
22-Feb-99	17:00	23.7	132	21.9	89	28.42	19.9	92
22-Feb-99	18:00	21.0	133	22.1	90	28.42	20.3	29
22-Feb-99	19:00	22.8	140	22.3	89	28.42	20.5	1
22-Feb-99	20:00	24.4	147	22.3	89	28.42	20.3	1
22-Feb-99	21:00	23.3	149	22.5	88	28.43	20.1	1
22-Feb-99	22:00	21.7	152	22.3	87	28.42	19.9	1
22-Feb-99	23:00	23.0	155	21.9	88	28.41	19.6	1
23-Feb-99	0:00	21.0	158	21.4	87	28.41	18.9	1
23-Feb-99	1:00	26.6	160	21.2	85	28.40	18.3	1
23-Feb-99	2:00	22.8	160	21.0	86	28.39	18.1	1
23-Feb-99	3:00	22.6	162	20.5	86	28.38	17.6	1
23-Feb-99	4:00	22.6	164	20.3	85	28.38	17.4	1
23-Feb-99	5:00	22.6	164	20.3	85	28.38	17.2	1
23-Feb-99	6:00	25.3	169	20.3	85	28.38	17.2	1
23-Feb-99	7:00	22.6	167	20.3	85	28.36	17.2	1
23-Feb-99	8:00	22.4	167	20.3	84	28.35	17.1	3

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
24-Feb-99	14:00	15.2	285	25.0	74	28.27	18.5	502
24-Feb-99	15:00	14.3	281	26.1	73	28.28	19.2	432
24-Feb-99	16:00	12.1	291	26.2	74	28.30	19.8	314
24-Feb-99	17:00	10.5	286	25.7	74	28.31	19.2	171
24-Feb-99	18:00	7.4	287	23.4	77	28.33	18.0	61
24-Feb-99	19:00	4.0	320	19.6	84	28.33	16.2	1
24-Feb-99	20:00	4.5	273	15.8	89	28.34	14.0	1
24-Feb-99	21:00	4.9	263	14.2	89	28.35	12.4	1
24-Feb-99	22:00	4.0	7	11.1	90	28.36	9.5	1
24-Feb-99	23:00	3.6	24	9.3	89	28.36	7.5	1
25-Feb-99	0:00	4.5	77	8.8	89	28.35	7.0	1
25-Feb-99	1:00	4.9	68	8.2	87	28.35	6.1	1
25-Feb-99	2:00	6.3	120	10.4	87	28.35	8.2	1
25-Feb-99	3:00	6.3	152	11.3	88	28.36	9.1	1
25-Feb-99	4:00	6.3	108	10.4	88	28.35	8.2	1
25-Feb-99	5:00	7.8	134	12.6	87	28.35	10.2	1
25-Feb-99	6:00	13.6	146	15.3	87	28.34	12.7	1
25-Feb-99	7:00	10.7	136	16.3	85	28.31	13.5	1
25-Feb-99	8:00	11.2	123	15.6	85	28.29	12.6	15
25-Feb-99	9:00	14.5	131	18.7	80	28.28	14.0	181
25-Feb-99	10:00	17.0	137	22.6	76	28.28	16.7	331
25-Feb-99	11:00	21.3	140	25.5	75	28.26	19.4	388
25-Feb-99	12:00	18.8	146	29.1	75	28.26	22.8	485
25-Feb-99	13:00	21.5	149	32.0	73	28.24	25.0	507
25-Feb-99	14:00	23.0	150	32.7	74	28.21	26.2	498
25-Feb-99	15:00	22.1	147	33.8	75	28.19	27.7	423
25-Feb-99	16:00	22.8	146	34.9	76	28.19	28.9	304
25-Feb-99	17:00	21.5	147	33.6	80	28.17	29.1	154
25-Feb-99	18:00	18.1	148	32.4	84	28.16	28.9	55

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
25-Feb-99	19:00	17.4	152	31.3	87	28.15	28.6	1
25-Feb-99	20:00	14.1	148	30.9	88	28.14	28.4	1
25-Feb-99	21:00	11.6	136	30.6	89	28.13	28.4	1
25-Feb-99	22:00	13.0	149	32.0	88	28.11	29.8	1
25-Feb-99	23:00	15.7	159	34.0	86	28.11	31.3	1
26-Feb-99	0:00	14.1	161	33.8	85	28.10	31.1	1
26-Feb-99	1:00	16.3	161	33.4	85	28.08	30.4	1
26-Feb-99	2:00	17.4	156	33.1	84	28.07	29.8	1
26-Feb-99	3:00	19.9	155	32.5	84	28.04	29.3	1
26-Feb-99	4:00	21.9	152	32.2	84	28.00	29.1	1
26-Feb-99	5:00	25.1	155	32.0	84	27.98	28.8	1
26-Feb-99	6:00	22.8	147	31.3	87	27.96	28.4	1
26-Feb-99	7:00	20.8	143	30.4	88	27.94	28.0	1
26-Feb-99	8:00	16.3	142	28.9	90	27.93	27.0	10
26-Feb-99	9:00	23.7	149	29.5	91	27.91	27.9	77
26-Feb-99	10:00	24.4	161	30.7	90	27.90	28.9	210
26-Feb-99	11:00	23.0	156	32.9	83	27.89	29.5	381
26-Feb-99	12:00	20.4	154	34.2	81	27.88	29.8	467
26-Feb-99	13:00	21.0	170	36.0	77	27.88	30.4	509
26-Feb-99	14:00	20.1	198	36.5	75	27.87	30.4	494
26-Feb-99	15:00	15.2	229	35.8	77	27.87	30.4	385
26-Feb-99	16:00	14.8	227	31.5	90	27.86	29.7	151
26-Feb-99	17:00	15.2	210	31.3	92	27.86	30.0	59
26-Feb-99	18:00	11.4	229	31.5	93	27.85	30.4	18
26-Feb-99	19:00	6.5	193	31.3	94	27.84	30.6	1
26-Feb-99	20:00	3.8	17	31.1	95	27.83	30.6	1
26-Feb-99	21:00	5.4	254	30.9	95	27.83	30.6	1
26-Feb-99	22:00	11.9	264	30.6	95	27.83	30.2	1
26-Feb-99	23:00	9.6	280	29.8	95	27.83	29.1	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
27-Feb-99	0:00	10.5	283	29.7	94	27.83	29.1	1
27-Feb-99	1:00	14.5	293	30.0	95	27.83	29.5	1
27-Feb-99	2:00	18.3	291	30.2	94	27.83	29.7	1
27-Feb-99	3:00	23.0	313	30.4	94	27.85	29.7	1
27-Feb-99	4:00	29.8	319	30.0	94	27.89	29.3	1
27-Feb-99	5:00	26.8	322	29.3	93	27.91	28.4	1
27-Feb-99	6:00	27.5	324	29.3	91	27.95	27.7	1
27-Feb-99	7:00	27.5	322	29.3	90	27.98	27.3	1
27-Feb-99	8:00	28.4	321	28.6	90	28.01	26.8	8
27-Feb-99	9:00	30.0	325	28.2	91	28.04	26.4	61
27-Feb-99	10:00	29.3	320	28.0	91	28.07	26.4	128
27-Feb-99	11:00	30.6	319	27.9	91	28.10	26.4	211
27-Feb-99	12:00	29.8	321	28.2	89	28.12	26.1	298
27-Feb-99	13:00	32.4	325	28.8	85	28.14	25.5	375
27-Feb-99	14:00	33.8	330	29.3	81	28.15	24.8	405
27-Feb-99	15:00	30.9	325	28.9	82	28.17	24.8	293
27-Feb-99	16:00	29.8	322	28.2	81	28.19	23.9	143
27-Feb-99	17:00	29.3	324	27.5	81	28.21	23.2	80
27-Feb-99	18:00	29.8	332	26.8	80	28.24	21.9	22
27-Feb-99	19:00	29.3	335	26.4	79	28.27	21.4	1
27-Feb-99	20:00	28.9	335	25.7	79	28.28	20.7	1
27-Feb-99	21:00	25.7	337	25.2	79	28.28	20.3	1
27-Feb-99	22:00	20.4	338	24.8	79	28.28	19.8	1
27-Feb-99	23:00	17.4	336	24.4	81	28.30	20.3	1
28-Feb-99	0:00	15.2	326	23.9	83	28.31	20.1	1
28-Feb-99	1:00	18.6	331	23.2	82	28.31	19.4	1
28-Feb-99	2:00	18.6	335	23.0	82	28.32	19.0	1
28-Feb-99	3:00	16.6	339	21.9	82	28.32	18.1	1
28-Feb-99	4:00	14.5	335	21.4	83	28.31	17.8	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
28-Feb-99	5:00	14.1	339	20.8	84	28.32	17.6	1
28-Feb-99	6:00	11.9	343	20.5	85	28.33	17.4	1
28-Feb-99	7:00	11.0	345	20.1	86	28.32	17.4	1
28-Feb-99	8:00	8.9	337	20.1	87	28.33	17.4	7
28-Feb-99	9:00	8.5	351	19.9	87	28.33	17.4	70
28-Feb-99	10:00	7.2	355	20.1	87	28.33	17.4	151
28-Feb-99	11:00	7.4	301	21.2	84	28.35	17.8	250
28-Feb-99	12:00	5.4	6	23.0	80	28.35	18.5	485
28-Feb-99	13:00	5.4	332	24.4	79	28.35	19.6	517
28-Feb-99	14:00	11.4	114	24.8	80	28.32	20.3	516
28-Feb-99	15:00	10.7	162	26.6	77	28.31	21.2	438
28-Feb-99	16:00	12.1	219	25.0	84	28.28	21.4	217
28-Feb-99	17:00	13.4	144	24.4	85	28.27	21.0	119
28-Feb-99	18:00	13.2	141	24.3	87	28.25	21.6	38
28-Feb-99	19:00	15.0	138	24.1	88	28.24	21.7	1
28-Feb-99	20:00	14.1	139	24.3	89	28.22	22.1	1
28-Feb-99	21:00	14.5	147	24.8	88	28.20	22.5	1
28-Feb-99	22:00	14.8	154	25.3	87	28.18	23.0	1
28-Feb-99	23:00	13.4	148	26.4	87	28.17	23.7	1
01-Mar-99	0:00	15.7	150	27.0	87	28.14	24.3	1
01-Mar-99	1:00	9.2	164	26.8	88	28.13	24.4	1
01-Mar-99	2:00	4.7	131	24.4	90	28.12	22.8	1
01-Mar-99	3:00	0.7	43	22.1	93	28.12	21.0	1
01-Mar-99	4:00	6.3	246	23.2	93	28.11	22.3	1
01-Mar-99	5:00	6.3	312	22.5	92	28.11	21.2	1
01-Mar-99	6:00	7.6	299	21.4	93	28.13	20.5	1
01-Mar-99	7:00	9.2	303	19.2	94	28.14	18.7	1
01-Mar-99	8:00	7.4	292	18.1	93	28.14	17.2	8
01-Mar-99	9:00	7.4	304	18.1	92	28.14	16.9	58

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
01-Mar-99	10:00	6.9	306	18.9	91	28.15	17.6	119
01-Mar-99	11:00	6.5	313	19.9	91	28.16	18.3	186
01-Mar-99	12:00	6.9	321	20.5	91	28.16	18.9	227
01-Mar-99	13:00	10.7	294	20.8	91	28.17	19.2	234
01-Mar-99	14:00	8.9	296	22.1	91	28.15	20.7	249
01-Mar-99	15:00	8.7	312	23.4	92	28.15	22.1	194
01-Mar-99	16:00	11.4	327	23.2	92	28.15	21.9	140
01-Mar-99	17:00	11.4	339	22.1	92	28.16	21.0	71
01-Mar-99	18:00	14.3	332	21.6	92	28.19	20.5	22
01-Mar-99	19:00	16.1	348	19.6	92	28.20	18.5	1
01-Mar-99	20:00	12.8	330	19.6	92	28.22	18.3	1
01-Mar-99	21:00	17.4	337	20.7	92	28.23	19.6	1
01-Mar-99	22:00	22.4	348	21.2	92	28.26	19.9	1
01-Mar-99	23:00	21.7	345	20.7	91	28.30	19.0	1
02-Mar-99	0:00	21.0	346	20.8	87	28.33	18.3	1
02-Mar-99	1:00	24.2	353	21.9	84	28.35	18.5	1
02-Mar-99	2:00	21.9	345	22.3	83	28.37	18.5	1
02-Mar-99	3:00	24.4	338	19.4	80	28.39	15.1	1
02-Mar-99	4:00	16.8	324	16.7	82	28.42	12.9	1
02-Mar-99	5:00	20.6	326	14.9	81	28.43	10.8	1
02-Mar-99	6:00	21.9	325	13.3	78	28.46	8.4	1
02-Mar-99	7:00	15.0	322	11.8	79	28.49	7.3	1
02-Mar-99	8:00	15.2	314	11.1	79	28.51	6.6	24
02-Mar-99	9:00	17.0	315	12.4	76	28.53	6.8	137
02-Mar-99	10:00	20.4	323	12.7	75	28.56	7.0	297
02-Mar-99	11:00	19.2	328	12.6	75	28.58	6.8	430
02-Mar-99	12:00	19.2	332	13.6	74	28.60	7.3	513
02-Mar-99	13:00	22.4	332	14.7	73	28.60	8.1	550
02-Mar-99	14:00	23.0	328	15.1	73	28.59	8.6	533

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
02-Mar-99	15:00	21.0	322	15.8	72	28.61	8.8	462
02-Mar-99	16:00	18.8	324	15.6	71	28.61	8.6	349
02-Mar-99	17:00	18.3	332	14.9	70	28.63	7.5	197
02-Mar-99	18:00	14.1	329	13.5	73	28.64	7.0	62
02-Mar-99	19:00	10.3	325	10.6	77	28.64	5.4	3
02-Mar-99	20:00	8.7	312	8.6	78	28.64	3.9	1
02-Mar-99	21:00	7.4	318	7.5	79	28.64	3.0	1
02-Mar-99	22:00	6.9	323	6.3	80	28.64	2.1	1
02-Mar-99	23:00	8.7	308	4.3	82	28.64	0.7	1
03-Mar-99	0:00	5.4	278	4.1	85	28.64	1.2	1
03-Mar-99	1:00	5.6	275	3.0	85	28.64	0.1	1
03-Mar-99	2:00	4.5	280	1.6	85	28.64	-1.3	1
03-Mar-99	3:00	2.9	73	-0.8	85	28.62	-3.6	1
03-Mar-99	4:00	0.0	356	-0.6	83	28.60	-3.6	1
03-Mar-99	5:00	3.6	305	-1.7	83	28.60	-4.9	1
03-Mar-99	6:00	0.0	32	-2.4	83	28.59	-5.8	1
03-Mar-99	7:00	0.0	287	-3.3	82	28.59	-6.7	1
03-Mar-99	8:00	3.1	31	-2.0	81	28.59	-5.8	58
03-Mar-99	9:00	3.8	72	1.0	80	28.56	-2.9	211
03-Mar-99	10:00	6.9	137	5.4	81	28.55	1.4	305
03-Mar-99	11:00	10.1	143	8.8	76	28.54	3.2	451
03-Mar-99	12:00	9.8	142	12.2	70	28.53	4.8	584
03-Mar-99	13:00	12.5	153	14.0	66	28.53	5.5	599
03-Mar-99	14:00	11.2	137	14.9	65	28.51	5.9	542
03-Mar-99	15:00	13.2	119	14.9	69	28.48	7.2	446
03-Mar-99	16:00	15.0	118	15.3	68	28.46	7.2	362
03-Mar-99	17:00	15.7	118	15.1	68	28.44	7.0	194
03-Mar-99	18:00	13.6	122	13.6	73	28.43	7.3	46
03-Mar-99	19:00	13.4	113	13.1	78	28.42	8.2	2

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
03-Mar-99	20:00	18.3	111	13.1	79	28.42	8.4	1
03-Mar-99	21:00	17.4	116	12.0	78	28.43	7.2	1
03-Mar-99	22:00	17.2	120	10.6	79	28.43	6.1	1
03-Mar-99	23:00	19.7	111	9.9	79	28.42	5.4	1
04-Mar-99	0:00	17.9	103	10.2	78	28.41	5.4	1
04-Mar-99	1:00	18.1	93	10.6	78	28.38	5.5	1
04-Mar-99	2:00	20.6	101	11.3	76	28.35	6.1	1
04-Mar-99	3:00	21.9	101	11.5	75	28.35	5.9	1
04-Mar-99	4:00	21.9	97	11.7	75	28.34	5.9	1
04-Mar-99	5:00	19.5	91	11.8	78	28.33	7.2	1
04-Mar-99	6:00	21.9	82	12.0	85	28.31	9.3	1
04-Mar-99	7:00	23.5	84	12.6	86	28.30	10.0	1
04-Mar-99	8:00	23.9	82	12.7	87	28.31	10.2	12
04-Mar-99	9:00	23.5	76	13.3	86	28.32	10.6	74
04-Mar-99	10:00	23.7	73	13.5	85	28.32	10.4	178
04-Mar-99	11:00	22.1	71	14.0	84	28.34	10.8	239
04-Mar-99	12:00	23.7	69	15.1	83	28.34	11.5	313
04-Mar-99	13:00	22.1	66	16.3	82	28.35	12.6	436
04-Mar-99	14:00	23.0	60	16.7	82	28.35	12.9	319
04-Mar-99	15:00	24.6	59	17.2	83	28.37	13.6	299
04-Mar-99	16:00	23.9	67	18.3	83	28.38	14.7	245
04-Mar-99	17:00	21.3	68	18.9	84	28.40	15.4	149
04-Mar-99	18:00	21.7	68	18.9	85	28.42	15.8	56
04-Mar-99	19:00	21.5	63	17.2	85	28.44	14.4	3
04-Mar-99	20:00	19.9	59	14.9	86	28.46	12.0	1
04-Mar-99	21:00	17.9	56	13.5	86	28.48	10.9	1
04-Mar-99	22:00	19.2	66	15.3	83	28.50	11.8	1
04-Mar-99	23:00	18.8	69	16.2	82	28.52	12.4	1
05-Mar-99	0:00	18.1	64	15.3	82	28.53	11.7	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
05-Mar-99	1:00	19.2	64	14.4	81	28.54	10.4	1
05-Mar-99	2:00	19.2	68	14.4	80	28.55	10.0	1
05-Mar-99	3:00	19.7	64	13.5	80	28.56	9.1	1
05-Mar-99	4:00	19.9	66	12.4	80	28.56	8.1	1
05-Mar-99	5:00	16.3	68	11.7	80	28.58	7.3	1
05-Mar-99	6:00	16.6	67	11.5	79	28.59	6.8	1
05-Mar-99	7:00	17.7	61	10.8	79	28.62	6.3	1
05-Mar-99	8:00	16.1	58	10.0	78	28.64	5.4	25
05-Mar-99	9:00	16.8	65	9.3	78	28.66	4.6	65
05-Mar-99	10:00	15.2	56	9.3	78	28.68	4.5	187
05-Mar-99	11:00	13.9	54	10.9	77	28.69	5.9	381
05-Mar-99	12:00	13.0	72	12.9	76	28.71	7.3	549
05-Mar-99	13:00	13.9	69	14.0	76	28.71	8.4	518
05-Mar-99	14:00	13.6	59	14.9	77	28.71	9.7	484
05-Mar-99	15:00	15.2	57	15.3	77	28.72	10.0	423
05-Mar-99	16:00	16.8	52	14.5	78	28.73	9.5	305
05-Mar-99	17:00	15.9	45	13.8	78	28.75	8.8	202
05-Mar-99	18:00	16.3	44	12.7	79	28.76	8.1	95
05-Mar-99	19:00	14.3	42	12.0	78	28.78	7.3	7
05-Mar-99	20:00	11.9	46	10.9	76	28.80	5.5	1
05-Mar-99	21:00	10.3	45	9.0	76	28.82	3.7	1
05-Mar-99	22:00	6.3	18	6.3	79	28.84	1.9	1
05-Mar-99	23:00	4.7	330	3.4	81	28.85	-0.4	1
06-Mar-99	0:00	6.9	293	0.3	84	28.86	-2.7	1
06-Mar-99	1:00	6.5	295	-2.9	83	28.87	-6.2	1
06-Mar-99	2:00	2.9	351	-4.0	81	28.88	-7.6	1
06-Mar-99	3:00	0.0	341	-4.5	81	28.89	-8.1	1
06-Mar-99	4:00	0.0	349	-5.1	81	28.89	-8.9	1
06-Mar-99	5:00	0.0	18	-6.7	80	28.90	-10.7	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
06-Mar-99	6:00	0.0	45	-8.1	79	28.92	-12.1	1
06-Mar-99	7:00	5.6	268	-9.6	79	28.92	-13.5	1
06-Mar-99	8:00	0.0	20	-9.4	79	28.92	-13.7	56
06-Mar-99	9:00	0.0	36	-4.4	79	28.90	-8.5	202
06-Mar-99	10:00	5.1	89	0.0	78	28.91	-4.5	347
06-Mar-99	11:00	7.6	136	7.0	70	28.92	0.0	469
06-Mar-99	12:00	6.9	98	11.3	65	28.92	2.3	507
06-Mar-99	13:00	8.1	105	12.6	64	28.91	3.4	487
06-Mar-99	14:00	9.2	123	14.5	63	28.90	4.6	552
06-Mar-99	15:00	10.7	125	15.4	60	28.89	4.3	481
06-Mar-99	16:00	11.0	123	15.4	63	28.89	5.4	374
06-Mar-99	17:00	13.0	122	14.7	64	28.87	5.2	214
06-Mar-99	18:00	13.0	124	12.7	67	28.85	4.6	53
06-Mar-99	19:00	14.1	126	12.0	73	28.84	5.5	2
06-Mar-99	20:00	14.3	127	12.2	75	28.84	6.3	1
06-Mar-99	21:00	14.5	131	12.6	79	28.83	7.9	1
06-Mar-99	22:00	17.0	145	13.5	81	28.83	9.3	1
06-Mar-99	23:00	18.3	150	16.0	78	28.83	10.9	1
07-Mar-99	0:00	17.4	151	16.5	76	28.81	11.1	1
07-Mar-99	1:00	18.6	153	16.7	76	28.80	10.9	1
07-Mar-99	2:00	16.3	151	14.4	77	28.80	9.3	1
07-Mar-99	3:00	14.8	148	13.1	78	28.78	8.1	1
07-Mar-99	4:00	15.2	145	11.7	78	28.76	6.8	1
07-Mar-99	5:00	15.0	140	9.7	80	28.76	5.5	1
07-Mar-99	6:00	13.9	139	10.2	80	28.75	6.1	1
07-Mar-99	7:00	12.8	127	11.8	81	28.73	8.1	1
07-Mar-99	8:00	12.8	137	13.3	81	28.72	9.1	23
07-Mar-99	9:00	15.0	139	14.5	80	28.72	10.2	92
07-Mar-99	10:00	14.5	133	16.5	79	28.71	11.8	190

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
07-Mar-99	11:00	16.6	139	19.0	77	28.70	13.8	286
07-Mar-99	12:00	20.4	144	21.6	77	28.69	16.0	373
07-Mar-99	13:00	23.5	148	23.2	77	28.66	18.0	449
07-Mar-99	14:00	23.0	140	24.6	78	28.63	19.4	487
07-Mar-99	15:00	25.3	137	24.8	79	28.61	19.9	422
07-Mar-99	16:00	23.0	133	25.0	81	28.59	20.7	264
07-Mar-99	17:00	24.8	130	24.3	82	28.58	20.3	142
07-Mar-99	18:00	25.3	132	23.9	82	28.56	20.1	50
07-Mar-99	19:00	28.2	131	23.4	82	28.53	19.4	2
07-Mar-99	20:00	25.5	130	22.1	86	28.53	19.2	1
07-Mar-99	21:00	26.6	129	21.4	88	28.52	19.2	1
07-Mar-99	22:00	23.9	134	20.8	89	28.51	18.9	1
07-Mar-99	23:00	23.9	138	20.7	89	28.50	18.7	1
08-Mar-99	0:00	23.0	137	21.0	88	28.48	18.9	1
08-Mar-99	1:00	25.3	134	21.2	87	28.46	18.7	1
08-Mar-99	2:00	24.6	136	21.2	88	28.45	19.0	1
08-Mar-99	3:00	28.9	140	21.4	86	28.43	18.9	1
08-Mar-99	4:00	27.1	138	21.4	87	28.41	19.0	1
08-Mar-99	5:00	26.2	138	21.4	88	28.40	19.0	1
08-Mar-99	6:00	26.4	139	21.0	90	28.39	19.2	1
08-Mar-99	7:00	22.6	140	20.7	89	28.38	18.9	1
08-Mar-99	8:00	24.4	137	20.7	89	28.38	18.9	4
08-Mar-99	9:00	21.7	140	20.7	89	28.39	18.9	46
08-Mar-99	10:00	23.5	143	21.0	88	28.40	18.9	118
08-Mar-99	11:00	21.7	141	21.9	87	28.40	19.4	284
08-Mar-99	12:00	21.3	140	22.5	85	28.38	19.2	397
08-Mar-99	13:00	22.6	146	23.0	84	28.39	19.6	371
08-Mar-99	14:00	23.5	148	22.6	83	28.39	19.0	251
08-Mar-99	15:00	19.7	146	22.5	83	28.38	18.9	267

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
08-Mar-99	16:00	17.4	138	22.3	84	28.39	18.9	190
08-Mar-99	17:00	16.1	135	22.1	84	28.38	18.7	122
08-Mar-99	18:00	15.4	141	21.6	85	28.39	18.5	53
08-Mar-99	19:00	14.1	141	21.4	86	28.41	18.5	4
08-Mar-99	20:00	11.6	140	21.0	86	28.41	18.1	1
08-Mar-99	21:00	11.6	135	20.5	87	28.41	18.0	1
08-Mar-99	22:00	7.6	127	19.9	88	28.42	17.8	1
08-Mar-99	23:00	5.8	112	18.7	90	28.41	16.9	1
09-Mar-99	0:00	5.8	96	16.3	90	28.42	14.5	1
09-Mar-99	1:00	0.7	30	12.9	90	28.43	11.3	1
09-Mar-99	2:00	0.0	314	11.5	91	28.43	9.9	1
09-Mar-99	3:00	0.0	341	15.3	90	28.44	13.6	1
09-Mar-99	4:00	0.0	357	16.3	90	28.44	14.7	1
09-Mar-99	5:00	0.0	16	16.3	90	28.45	14.7	1
09-Mar-99	6:00	0.0	22	16.3	90	28.47	14.7	1
09-Mar-99	7:00	0.0	26	16.9	90	28.47	15.4	1
09-Mar-99	8:00	0.0	23	17.8	90	28.48	16.2	27
09-Mar-99	9:00	9.8	71	19.6	89	28.49	17.8	163
09-Mar-99	10:00	10.5	131	19.0	89	28.50	17.1	235
09-Mar-99	11:00	5.4	85	20.1	85	28.52	17.1	429
09-Mar-99	12:00	6.3	62	19.9	84	28.54	16.5	521
09-Mar-99	13:00	8.1	80	20.1	85	28.56	16.9	519
09-Mar-99	14:00	7.2	82	20.8	84	28.56	17.4	466
09-Mar-99	15:00	8.1	101	20.7	86	28.55	17.8	368
09-Mar-99	16:00	11.0	109	20.3	86	28.55	17.4	287
09-Mar-99	17:00	13.4	117	20.5	85	28.55	17.4	170
09-Mar-99	18:00	14.1	106	19.9	86	28.54	17.2	54
09-Mar-99	19:00	12.3	127	19.4	86	28.55	16.5	2
09-Mar-99	20:00	9.4	127	19.6	86	28.57	16.9	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
09-Mar-99	21:00	9.2	138	19.6	86	28.58	16.7	1
09-Mar-99	22:00	7.6	104	18.1	88	28.59	16.0	1
09-Mar-99	23:00	8.3	123	18.1	90	28.60	16.3	1
10-Mar-99	0:00	6.0	128	17.6	90	28.61	15.8	1
10-Mar-99	1:00	6.5	104	17.4	90	28.61	16.0	1
10-Mar-99	2:00	7.6	104	17.2	91	28.61	15.8	1
10-Mar-99	3:00	5.1	96	17.4	90	28.61	15.8	1
10-Mar-99	4:00	6.3	95	17.6	90	28.61	15.8	1
10-Mar-99	5:00	6.7	104	18.5	90	28.62	16.9	1
10-Mar-99	6:00	7.4	117	19.4	90	28.64	17.6	1
10-Mar-99	7:00	7.2	117	19.6	90	28.66	18.0	1
10-Mar-99	8:00	7.6	111	19.2	90	28.67	17.4	34
10-Mar-99	9:00	6.9	91	19.8	86	28.67	17.1	178
10-Mar-99	10:00	9.6	104	20.5	85	28.69	17.4	275
10-Mar-99	11:00	15.2	126	21.2	88	28.69	18.9	361
10-Mar-99	12:00	13.6	142	23.2	85	28.70	20.1	389
10-Mar-99	13:00	12.3	124	24.8	82	28.70	20.7	542
10-Mar-99	14:00	12.1	111	25.0	82	28.70	20.8	400
10-Mar-99	15:00	12.5	118	25.2	80	28.70	20.7	336
10-Mar-99	16:00	13.4	119	24.3	86	28.70	21.2	279
10-Mar-99	17:00	13.0	139	24.3	81	28.71	19.9	208
10-Mar-99	18:00	11.2	126	21.7	81	28.72	17.6	63
10-Mar-99	19:00	8.1	135	19.4	82	28.73	15.6	5
10-Mar-99	20:00	6.0	123	18.1	89	28.74	16.2	1
10-Mar-99	21:00	6.5	121	18.3	90	28.75	16.5	1
10-Mar-99	22:00	6.5	124	17.1	88	28.76	14.9	1
10-Mar-99	23:00	5.6	113	12.7	90	28.75	10.9	1
11-Mar-99	0:00	6.9	112	11.8	91	28.75	10.6	1
11-Mar-99	1:00	5.8	104	10.9	89	28.76	9.0	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
11-Mar-99	2:00	4.9	139	9.5	88	28.76	7.5	1
11-Mar-99	3:00	4.0	186	12.7	89	28.76	10.9	1
11-Mar-99	4:00	2.9	106	13.8	89	28.76	12.0	1
11-Mar-99	5:00	5.4	102	11.3	88	28.76	9.3	1
11-Mar-99	6:00	7.6	116	10.0	88	28.77	7.7	1
11-Mar-99	7:00	7.2	146	11.3	88	28.77	9.1	1
11-Mar-99	8:00	4.7	150	11.5	88	28.78	9.3	28
11-Mar-99	9:00	6.3	146	12.7	88	28.78	10.8	110
11-Mar-99	10:00	6.0	146	14.7	88	28.78	12.6	251
11-Mar-99	11:00	14.8	145	18.1	89	28.79	16.2	337
11-Mar-99	12:00	14.1	146	20.7	88	28.79	18.3	414
11-Mar-99	13:00	13.6	145	22.3	86	28.79	19.4	503
11-Mar-99	14:00	15.0	145	23.7	82	28.77	19.6	497
11-Mar-99	15:00	15.2	152	25.2	76	28.76	19.0	475
11-Mar-99	16:00	13.4	145	24.3	78	28.75	19.0	272
11-Mar-99	17:00	13.6	146	24.1	81	28.73	19.6	155
11-Mar-99	18:00	11.9	145	23.9	83	28.73	20.1	59
11-Mar-99	19:00	10.1	140	23.4	85	28.73	20.1	4
11-Mar-99	20:00	9.6	139	22.6	85	28.74	19.6	1
11-Mar-99	21:00	9.6	122	21.4	85	28.74	18.3	1
11-Mar-99	22:00	10.1	121	19.4	87	28.74	16.9	1
11-Mar-99	23:00	8.3	127	18.5	87	28.75	16.2	1
12-Mar-99	0:00	8.7	136	17.6	87	28.75	15.1	1
12-Mar-99	1:00	7.4	138	16.7	87	28.74	14.2	1
12-Mar-99	2:00	4.7	130	15.4	87	28.74	12.9	1
12-Mar-99	3:00	6.3	135	14.7	88	28.74	12.4	1
12-Mar-99	4:00	7.4	126	15.3	85	28.73	12.6	1
12-Mar-99	5:00	8.3	136	15.4	84	28.73	12.4	1
12-Mar-99	6:00	11.6	154	15.6	88	28.73	13.6	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
12-Mar-99	7:00	9.2	159	15.4	92	28.73	14.2	1
12-Mar-99	8:00	8.5	140	15.3	92	28.74	14.0	44
12-Mar-99	9:00	11.4	143	15.3	90	28.73	13.5	154
12-Mar-99	10:00	11.6	137	16.3	88	28.73	14.0	263
12-Mar-99	11:00	10.5	141	18.9	85	28.73	16.0	464
12-Mar-99	12:00	11.0	138	22.5	80	28.74	18.1	563
12-Mar-99	13:00	12.3	141	24.8	77	28.73	19.4	539
12-Mar-99	14:00	13.2	150	25.9	76	28.71	19.9	451
12-Mar-99	15:00	12.8	156	25.7	75	28.70	19.4	350
12-Mar-99	16:00	13.2	181	25.2	77	28.70	19.6	234
12-Mar-99	17:00	13.6	167	25.2	79	28.69	20.3	139
12-Mar-99	18:00	9.6	149	25.0	82	28.69	20.8	47
12-Mar-99	19:00	8.1	130	24.8	84	28.68	21.4	3
12-Mar-99	20:00	9.4	129	24.1	88	28.67	21.7	1
12-Mar-99	21:00	10.1	131	23.9	88	28.68	21.6	1
12-Mar-99	22:00	13.0	140	23.9	88	28.67	21.6	1
12-Mar-99	23:00	11.9	144	23.5	88	28.67	21.4	1
13-Mar-99	0:00	10.5	139	23.7	88	28.66	21.4	1
13-Mar-99	1:00	11.0	139	23.4	88	28.65	21.0	1
13-Mar-99	2:00	11.4	149	23.7	87	28.64	21.4	1
13-Mar-99	3:00	9.2	162	24.4	87	28.64	21.9	1
13-Mar-99	4:00	8.9	160	25.0	88	28.63	22.6	1
13-Mar-99	5:00	8.5	153	25.5	89	28.63	23.4	1
13-Mar-99	6:00	7.6	143	25.5	89	28.63	23.4	1
13-Mar-99	7:00	8.1	138	25.7	89	28.64	23.5	1
13-Mar-99	8:00	9.4	137	25.9	88	28.64	23.5	19
13-Mar-99	9:00	13.6	144	26.2	87	28.64	23.5	91
13-Mar-99	10:00	13.9	146	27.1	85	28.64	23.9	207
13-Mar-99	11:00	13.4	156	28.9	80	28.65	24.3	348

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
13-Mar-99	12:00	14.8	180	31.6	73	28.64	24.8	511
13-Mar-99	13:00	14.3	182	32.5	69	28.65	24.4	600
13-Mar-99	14:00	16.1	185	32.4	69	28.64	24.4	568
13-Mar-99	15:00	18.1	184	31.6	72	28.62	24.4	394
13-Mar-99	16:00	17.0	177	31.3	74	28.61	24.4	256
13-Mar-99	17:00	15.0	151	30.6	79	28.61	25.7	151
13-Mar-99	18:00	14.1	152	29.8	82	28.60	25.7	44
13-Mar-99	19:00	14.1	143	29.3	84	28.58	25.9	5
13-Mar-99	20:00	14.5	145	28.4	85	28.57	25.3	1
13-Mar-99	21:00	13.4	144	26.8	87	28.57	24.1	1
13-Mar-99	22:00	15.2	144	26.1	87	28.56	23.2	1
13-Mar-99	23:00	16.1	147	25.3	86	28.56	22.6	1
14-Mar-99	0:00	13.6	143	24.3	84	28.55	20.8	1
14-Mar-99	1:00	13.0	148	23.2	84	28.53	19.8	1
14-Mar-99	2:00	11.0	157	22.3	86	28.53	19.4	1
14-Mar-99	3:00	11.0	157	20.8	88	28.51	18.7	1
14-Mar-99	4:00	11.0	157	20.5	88	28.48	18.3	1
14-Mar-99	5:00	11.2	157	21.4	86	28.47	18.5	1
14-Mar-99	6:00	12.5	175	22.3	83	28.46	18.7	1
14-Mar-99	7:00	10.3	159	21.0	83	28.46	17.6	2
14-Mar-99	8:00	8.1	148	21.2	82	28.44	17.4	75
14-Mar-99	9:00	10.3	152	23.0	79	28.43	18.3	199
14-Mar-99	10:00	12.1	168	27.1	73	28.42	20.3	346
14-Mar-99	11:00	11.2	153	29.3	71	28.41	21.9	506
14-Mar-99	12:00	13.0	151	31.8	70	28.40	24.1	583
14-Mar-99	13:00	14.8	158	33.4	68	28.38	25.0	578
14-Mar-99	14:00	19.0	176	35.2	68	28.35	26.8	582
14-Mar-99	15:00	17.2	161	35.2	71	28.34	27.9	453
14-Mar-99	16:00	19.2	163	35.2	72	28.31	28.4	338

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
14-Mar-99	17:00	16.3	158	35.2	74	28.31	28.9	228
14-Mar-99	18:00	13.0	162	35.4	75	28.30	29.3	86
14-Mar-99	19:00	12.5	169	34.0	79	28.27	29.3	9
14-Mar-99	20:00	12.5	169	33.6	81	28.26	29.5	1
14-Mar-99	21:00	13.2	161	34.0	81	28.24	30.0	1
14-Mar-99	22:00	13.0	162	34.7	81	28.22	30.6	1
14-Mar-99	23:00	14.1	169	34.3	82	28.20	30.6	1
15-Mar-99	0:00	12.1	170	33.6	83	28.18	30.0	1
15-Mar-99	1:00	10.5	160	33.1	83	28.17	29.5	1
15-Mar-99	2:00	7.8	145	32.7	83	28.16	29.1	1
15-Mar-99	3:00	8.7	165	32.7	82	28.14	29.1	1
15-Mar-99	4:00	7.2	135	30.9	85	28.12	27.5	1
15-Mar-99	5:00	6.9	139	29.5	87	28.10	27.0	1
15-Mar-99	6:00	5.6	146	28.9	87	28.09	26.4	1
15-Mar-99	7:00	6.3	105	29.5	85	28.08	26.2	2
15-Mar-99	8:00	11.4	185	34.9	73	28.06	28.2	66
15-Mar-99	9:00	11.9	205	38.7	65	28.06	28.6	215
15-Mar-99	10:00	13.4	201	41.9	57	28.06	28.6	359
15-Mar-99	11:00	16.3	218	41.5	60	28.06	29.5	487
15-Mar-99	12:00	17.9	227	41.0	63	28.05	30.2	599
15-Mar-99	13:00	16.1	231	40.3	66	28.05	30.7	615
15-Mar-99	14:00	16.3	250	40.3	67	28.06	31.3	510
15-Mar-99	15:00	15.4	270	38.8	71	28.08	31.3	461
15-Mar-99	16:00	17.0	286	37.9	73	28.09	30.9	384
15-Mar-99	17:00	18.1	287	36.9	74	28.09	30.2	224
15-Mar-99	18:00	18.3	287	34.7	79	28.11	29.8	82
15-Mar-99	19:00	16.3	292	32.7	83	28.12	29.3	10
15-Mar-99	20:00	12.8	289	31.5	87	28.14	28.6	1
15-Mar-99	21:00	11.6	284	30.4	87	28.17	27.9	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
15-Mar-99	22:00	10.5	292	28.9	89	28.17	27.0	1
15-Mar-99	23:00	9.4	292	28.0	90	28.18	26.2	1
16-Mar-99	0:00	6.9	284	26.8	92	28.18	25.3	1
16-Mar-99	1:00	9.8	307	26.1	92	28.17	25.0	1
16-Mar-99	2:00	8.1	333	25.7	92	28.17	24.6	1
16-Mar-99	3:00	4.3	19	24.1	93	28.15	23.2	1
16-Mar-99	4:00	3.6	354	23.5	94	28.14	22.8	1
16-Mar-99	5:00	3.6	324	22.5	94	28.13	21.7	1
16-Mar-99	6:00	1.1	15	21.2	93	28.12	20.5	1
16-Mar-99	7:00	3.6	18	19.8	94	28.13	19.0	2
16-Mar-99	8:00	2.2	38	21.0	94	28.13	20.5	73
16-Mar-99	9:00	6.5	82	22.5	92	28.13	21.4	194
16-Mar-99	10:00	11.9	105	26.2	85	28.11	23.2	202
16-Mar-99	11:00	18.1	126	30.9	70	28.10	22.8	365
16-Mar-99	12:00	17.4	119	32.7	68	28.08	24.4	566
16-Mar-99	13:00	18.3	107	33.6	70	28.06	25.7	573
16-Mar-99	14:00	19.2	111	33.6	72	28.02	26.4	555
16-Mar-99	15:00	20.4	99	33.6	75	27.99	27.5	474
16-Mar-99	16:00	18.3	90	34.3	74	27.97	27.9	380
16-Mar-99	17:00	19.9	94	33.8	76	27.96	28.2	218
16-Mar-99	18:00	17.4	102	32.4	79	27.92	27.7	65
16-Mar-99	19:00	16.8	102	32.0	77	27.91	26.4	5
16-Mar-99	20:00	16.3	97	31.3	76	27.90	25.2	1
16-Mar-99	21:00	12.8	71	31.8	74	27.93	25.2	1
16-Mar-99	22:00	11.0	60	31.8	79	27.92	26.6	1
16-Mar-99	23:00	11.4	57	31.8	77	27.90	26.1	1
17-Mar-99	0:00	9.6	7	31.6	80	27.91	26.6	1
17-Mar-99	1:00	7.6	126	30.0	91	27.92	28.4	1
17-Mar-99	2:00	4.0	328	29.3	95	27.91	28.8	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
17-Mar-99	3:00	3.8	340	29.1	95	27.90	28.6	1
17-Mar-99	4:00	8.1	332	28.9	95	27.89	28.6	1
17-Mar-99	5:00	17.0	7	28.0	94	27.91	27.1	1
17-Mar-99	6:00	30.9	9	26.4	92	27.94	25.2	1
17-Mar-99	7:00	37.1	0	26.1	94	28.00	25.3	1
17-Mar-99	8:00	33.3	344	26.6	94	28.09	26.1	27
17-Mar-99	9:00	31.8	334	27.1	93	28.16	26.2	117
17-Mar-99	10:00	34.0	323	28.2	91	28.22	26.6	239
17-Mar-99	11:00	33.1	319	29.5	87	28.27	26.8	350
17-Mar-99	12:00	40.3	326	30.0	81	28.31	25.5	550
17-Mar-99	13:00	32.0	323	30.4	80	28.35	25.7	610
17-Mar-99	14:00	30.2	321	30.6	78	28.38	25.2	571
17-Mar-99	15:00	27.7	322	30.4	75	28.41	24.1	502
17-Mar-99	16:00	22.1	319	31.1	75	28.46	24.6	382
17-Mar-99	17:00	19.5	308	31.5	74	28.49	24.8	231
17-Mar-99	18:00	20.8	301	29.7	76	28.52	23.5	87
17-Mar-99	19:00	21.0	299	27.7	78	28.53	22.3	11
17-Mar-99	20:00	20.4	291	25.7	78	28.55	20.7	1
17-Mar-99	21:00	20.6	288	24.8	78	28.57	19.6	1
17-Mar-99	22:00	20.4	286	23.2	82	28.59	19.4	1
17-Mar-99	23:00	16.3	293	22.5	84	28.61	18.9	1
18-Mar-99	0:00	15.9	291	21.4	86	28.64	18.7	1
18-Mar-99	1:00	12.1	288	19.9	86	28.65	17.1	1
18-Mar-99	2:00	10.5	292	18.5	86	28.67	16.0	1
18-Mar-99	3:00	8.7	287	17.4	87	28.69	14.9	1
18-Mar-99	4:00	8.9	278	16.3	87	28.70	14.0	1
18-Mar-99	5:00	6.5	260	15.3	88	28.72	13.3	1
18-Mar-99	6:00	6.5	270	14.4	89	28.74	12.6	1
18-Mar-99	7:00	5.4	291	13.5	89	28.76	11.5	9

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
18-Mar-99	8:00	4.7	319	15.3	85	28.78	12.2	140
18-Mar-99	9:00	5.8	264	17.6	84	28.79	14.2	258
18-Mar-99	10:00	4.7	319	20.5	79	28.83	15.8	470
18-Mar-99	11:00	4.9	338	23.4	78	28.85	18.1	605
18-Mar-99	12:00	6.3	73	25.9	75	28.85	19.8	606
18-Mar-99	13:00	10.1	132	28.8	72	28.83	21.4	622
18-Mar-99	14:00	9.4	191	31.8	66	28.83	22.5	591
18-Mar-99	15:00	8.7	204	33.8	60	28.82	22.1	515
18-Mar-99	16:00	10.5	161	34.7	58	28.81	22.3	393
18-Mar-99	17:00	11.0	137	33.3	68	28.79	24.8	239
18-Mar-99	18:00	11.9	137	31.6	75	28.77	25.3	93
18-Mar-99	19:00	11.4	136	28.8	82	28.76	24.8	13
18-Mar-99	20:00	12.5	138	26.4	86	28.74	23.5	1
18-Mar-99	21:00	12.5	141	25.5	83	28.74	21.9	1
18-Mar-99	22:00	14.3	141	25.2	82	28.73	21.2	1
18-Mar-99	23:00	15.9	144	25.5	85	28.72	22.5	1
19-Mar-99	0:00	14.8	148	26.1	84	28.73	22.8	1
19-Mar-99	1:00	16.6	146	26.6	79	28.71	21.7	1
19-Mar-99	2:00	15.7	151	25.7	81	28.70	21.4	1
19-Mar-99	3:00	19.0	154	27.0	80	28.69	22.3	1
19-Mar-99	4:00	18.3	151	27.7	76	28.68	21.7	1
19-Mar-99	5:00	17.7	148	27.9	75	28.66	21.6	1
19-Mar-99	6:00	17.0	149	27.3	75	28.66	21.4	1
19-Mar-99	7:00	18.8	148	27.9	74	28.64	21.0	5
19-Mar-99	8:00	18.8	155	29.8	69	28.62	21.6	92
19-Mar-99	9:00	21.9	183	31.5	68	28.61	22.8	246
19-Mar-99	10:00	19.9	189	33.1	67	28.59	24.3	402
19-Mar-99	11:00	20.8	192	35.8	65	28.58	25.9	524
19-Mar-99	12:00	18.3	170	38.3	64	28.58	28.0	606

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
19-Mar-99	13:00	18.6	176	39.9	64	28.56	29.5	611
19-Mar-99	14:00	19.2	176	41.9	63	28.54	31.1	608
19-Mar-99	15:00	20.4	183	42.8	64	28.51	32.0	470
19-Mar-99	16:00	14.8	196	43.5	64	28.49	32.5	395
19-Mar-99	17:00	12.1	190	44.8	63	28.48	33.1	230
19-Mar-99	18:00	12.1	214	43.2	64	28.47	32.2	90
19-Mar-99	19:00	11.6	241	41.7	66	28.46	31.8	14
19-Mar-99	20:00	10.7	241	37.9	73	28.45	31.1	1
19-Mar-99	21:00	11.6	255	37.9	72	28.46	30.7	1
19-Mar-99	22:00	16.8	287	34.5	79	28.46	29.8	1
19-Mar-99	23:00	16.6	292	32.2	85	28.48	29.3	1
20-Mar-99	0:00	15.0	298	31.6	86	28.49	28.8	1
20-Mar-99	1:00	18.8	312	31.3	85	28.52	28.0	1
20-Mar-99	2:00	18.8	309	30.2	84	28.54	26.6	1
20-Mar-99	3:00	18.3	305	28.8	86	28.56	26.1	1
20-Mar-99	4:00	17.9	307	28.4	86	28.58	25.3	1
20-Mar-99	5:00	16.3	307	27.1	87	28.59	24.4	1
20-Mar-99	6:00	14.3	303	26.2	88	28.62	23.9	1
20-Mar-99	7:00	13.4	295	25.5	89	28.64	23.4	8
20-Mar-99	8:00	15.9	297	25.9	89	28.67	23.9	60
20-Mar-99	9:00	15.0	296	27.5	88	28.68	25.2	156
20-Mar-99	10:00	17.2	291	28.8	86	28.70	25.7	410
20-Mar-99	11:00	17.7	302	29.5	86	28.71	26.6	317
20-Mar-99	12:00	18.8	311	30.7	84	28.73	27.1	386
20-Mar-99	13:00	18.8	312	32.0	81	28.74	27.9	585
20-Mar-99	14:00	17.4	314	32.7	81	28.75	28.6	559
20-Mar-99	15:00	17.4	310	33.4	79	28.75	28.8	498
20-Mar-99	16:00	15.9	305	33.8	80	28.75	29.5	368
20-Mar-99	17:00	15.2	317	33.6	77	28.75	28.2	226

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
20-Mar-99	18:00	11.2	322	32.7	80	28.75	28.2	88
20-Mar-99	19:00	9.8	317	30.4	86	28.74	27.3	12
20-Mar-99	20:00	5.1	308	27.9	90	28.73	26.1	1
20-Mar-99	21:00	6.7	289	26.4	92	28.73	25.2	1
20-Mar-99	22:00	7.2	274	25.5	93	28.73	24.4	1
20-Mar-99	23:00	6.3	288	24.4	93	28.73	23.5	1
21-Mar-99	0:00	7.6	289	23.4	93	28.72	22.3	1
21-Mar-99	1:00	6.0	276	23.0	93	28.72	21.9	1
21-Mar-99	2:00	6.0	304	22.6	93	28.73	21.6	1
21-Mar-99	3:00	2.9	8	22.5	92	28.73	21.4	1
21-Mar-99	4:00	1.8	1	21.0	93	28.72	19.9	1
21-Mar-99	5:00	0.0	42	20.5	92	28.71	19.6	1
21-Mar-99	6:00	3.6	290	19.6	93	28.71	18.5	1
21-Mar-99	7:00	0.0	13	19.6	92	28.71	18.5	13
21-Mar-99	8:00	0.0	22	21.9	87	28.71	19.4	147
21-Mar-99	11:00	4.5	349	30.9	81	28.76	26.6	519
21-Mar-99	12:00	8.1	64	33.4	73	28.74	26.6	594
21-Mar-99	13:00	8.5	138	34.7	65	28.72	25.0	618
21-Mar-99	14:00	9.8	125	35.4	62	28.70	24.6	581
21-Mar-99	15:00	10.7	133	35.8	54	28.68	21.6	504
21-Mar-99	16:00	9.8	125	36.0	52	28.67	20.7	390
21-Mar-99	17:00	9.6	140	36.1	50	28.66	20.1	240
21-Mar-99	18:00	8.1	132	35.6	49	28.65	19.0	96
21-Mar-99	19:00	5.1	97	32.0	61	28.65	20.8	14
21-Mar-99	20:00	0.0	99	28.4	74	28.64	21.7	1
21-Mar-99	21:00	0.0	84	27.0	76	28.63	20.8	1
21-Mar-99	22:00	0.0	62	26.1	70	28.63	18.3	1
21-Mar-99	23:00	5.6	104	25.9	72	28.63	18.7	1
22-Mar-99	0:00	0.0	64	24.1	79	28.62	19.2	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
22-Mar-99	1:00	0.0	100	23.7	80	28.61	19.2	1
22-Mar-99	2:00	0.0	60	22.6	82	28.61	18.9	1
22-Mar-99	3:00	0.0	64	21.7	86	28.59	18.9	1
22-Mar-99	4:00	0.0	62	21.0	88	28.59	18.9	1
22-Mar-99	5:00	0.0	65	20.5	88	28.59	18.3	1
22-Mar-99	6:00	4.7	122	20.3	88	28.59	18.0	1
22-Mar-99	7:00	3.8	40	20.1	87	28.60	17.6	19
22-Mar-99	8:00	4.7	97	23.2	77	28.60	17.6	172
22-Mar-99	9:00	0.0	0	27.1	68	28.62	18.3	362
22-Mar-99	10:00	6.9	214	32.0	57	28.64	19.2	439
22-Mar-99	11:00	7.4	240	33.8	58	28.64	21.6	537
22-Mar-99	12:00	8.5	267	34.7	61	28.64	23.7	606
22-Mar-99	13:00	7.8	293	36.0	64	28.64	25.9	627
22-Mar-99	14:00	5.6	320	37.8	64	28.63	27.7	589
22-Mar-99	15:00	5.4	316	39.0	58	28.62	26.4	511
22-Mar-99	16:00	6.5	304	39.4	60	28.61	27.3	397
22-Mar-99	17:00	6.7	327	38.7	61	28.60	27.3	246
22-Mar-99	18:00	6.0	339	37.8	61	28.59	26.6	101
22-Mar-99	19:00	0.0	13	34.9	71	28.57	27.5	16
22-Mar-99	20:00	0.0	14	31.5	80	28.55	26.6	1
22-Mar-99	21:00	0.0	349	28.4	83	28.53	24.8	1
22-Mar-99	22:00	0.0	14	26.6	86	28.53	23.7	1
22-Mar-99	23:00	0.0	21	25.3	89	28.53	23.4	1
23-Mar-99	0:00	0.0	297	24.4	89	28.53	22.5	1
23-Mar-99	1:00	5.6	287	25.0	88	28.52	22.8	1
23-Mar-99	2:00	4.9	318	25.0	85	28.51	21.7	1
23-Mar-99	3:00	6.0	268	24.1	85	28.50	20.8	1
23-Mar-99	4:00	7.2	290	23.2	86	28.49	20.5	1
23-Mar-99	5:00	4.7	328	21.4	88	28.48	19.0	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
23-Mar-99	6:00	6.9	310	20.8	88	28.48	18.5	1
23-Mar-99	7:00	8.7	293	21.6	86	28.49	18.7	19
23-Mar-99	8:00	7.6	290	21.9	84	28.50	18.5	165
23-Mar-99	9:00	10.7	359	26.1	76	28.52	20.3	317
23-Mar-99	10:00	15.4	25	27.7	65	28.53	18.1	479
23-Mar-99	11:00	14.3	26	28.4	65	28.55	18.5	551
23-Mar-99	12:00	14.3	29	28.9	63	28.56	18.7	614
23-Mar-99	13:00	17.2	15	29.1	58	28.57	16.9	634
23-Mar-99	14:00	17.0	16	29.3	58	28.58	17.1	595
23-Mar-99	15:00	16.3	9	28.9	63	28.58	18.5	515
23-Mar-99	16:00	16.3	8	28.4	67	28.58	19.4	400
23-Mar-99	17:00	17.0	29	27.7	69	28.59	19.6	255
23-Mar-99	18:00	18.1	28	26.4	70	28.60	18.7	106
23-Mar-99	19:00	17.9	40	24.8	77	28.60	19.2	17
23-Mar-99	20:00	17.0	47	23.9	80	28.61	19.4	1
23-Mar-99	21:00	17.7	46	23.9	80	28.63	19.2	1
23-Mar-99	22:00	14.1	45	23.0	83	28.64	19.4	1
23-Mar-99	23:00	6.5	28	21.6	87	28.65	19.0	1
24-Mar-99	0:00	4.3	350	20.7	88	28.67	18.5	1
24-Mar-99	1:00	4.7	348	19.4	90	28.69	17.8	1
24-Mar-99	2:00	4.9	345	18.1	90	28.71	16.7	1
24-Mar-99	3:00	6.9	327	17.2	90	28.72	15.6	1
24-Mar-99	4:00	6.5	323	16.2	90	28.73	14.7	1
24-Mar-99	5:00	5.4	7	15.8	91	28.75	14.4	1
24-Mar-99	6:00	3.4	359	15.8	91	28.76	14.4	1
24-Mar-99	7:00	0.0	321	14.2	90	28.77	12.6	29
24-Mar-99	8:00	3.6	316	16.0	87	28.79	13.6	181
24-Mar-99	9:00	7.2	12	20.1	85	28.82	16.9	313
24-Mar-99	10:00	8.1	55	23.4	77	28.84	18.0	443

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
24-Mar-99	11:00	9.4	96	26.1	68	28.86	17.6	646
24-Mar-99	12:00	5.8	53	27.9	62	28.88	17.2	658
24-Mar-99	13:00	6.9	309	28.8	62	28.89	17.8	641
24-Mar-99	14:00	8.7	18	29.8	56	28.89	16.7	601
24-Mar-99	15:00	13.9	28	30.4	59	28.86	18.1	521
24-Mar-99	16:00	8.7	24	30.6	58	28.86	18.0	406
24-Mar-99	17:00	8.7	50	30.6	60	28.85	19.0	256
24-Mar-99	18:00	7.4	90	30.0	59	28.84	18.0	107
24-Mar-99	19:00	5.6	85	27.5	68	28.82	18.9	18
24-Mar-99	20:00	0.0	40	25.2	76	28.81	19.2	1
24-Mar-99	21:00	0.0	23	23.5	83	28.81	19.9	1
24-Mar-99	22:00	0.0	43	22.1	87	28.80	19.4	1
24-Mar-99	23:00	0.0	327	20.8	85	28.80	17.8	1
25-Mar-99	0:00	0.0	57	19.9	88	28.80	17.8	1
25-Mar-99	1:00	0.0	99	19.9	88	28.80	17.6	1
25-Mar-99	2:00	6.3	139	19.6	86	28.80	16.7	1
25-Mar-99	3:00	9.4	143	19.4	86	28.80	16.5	1
25-Mar-99	4:00	7.8	171	19.9	85	28.79	17.1	1
25-Mar-99	5:00	8.5	155	19.8	86	28.77	17.1	1
25-Mar-99	6:00	6.5	146	18.7	88	28.77	16.5	1
25-Mar-99	7:00	11.0	154	19.8	87	28.77	17.2	20
25-Mar-99	8:00	15.4	162	22.3	82	28.76	18.1	161
25-Mar-99	9:00	18.1	166	25.7	70	28.75	18.0	370
25-Mar-99	10:00	21.7	175	27.5	68	28.75	19.0	505
25-Mar-99	11:00	18.1	163	30.2	65	28.74	20.5	555
25-Mar-99	12:00	19.0	165	32.7	59	28.74	21.0	618
25-Mar-99	13:00	21.9	149	33.4	64	28.71	23.4	635
25-Mar-99	14:00	23.5	146	34.3	66	28.68	25.0	597
25-Mar-99	15:00	21.3	145	35.2	66	28.66	26.1	514

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
25-Mar-99	16:00	24.2	147	35.8	66	28.62	26.4	398
25-Mar-99	17:00	23.7	148	36.3	63	28.59	26.1	250
25-Mar-99	18:00	23.0	153	36.1	64	28.57	26.2	108
25-Mar-99	19:00	19.5	154	34.3	69	28.55	26.1	18
25-Mar-99	20:00	22.1	151	33.6	66	28.51	24.4	1
25-Mar-99	21:00	28.2	155	35.4	56	28.49	22.1	1
25-Mar-99	22:00	29.5	174	35.8	51	28.47	20.5	1
25-Mar-99	23:00	29.8	175	34.5	55	28.45	21.0	1
26-Mar-99	0:00	28.9	181	34.0	56	28.43	21.0	1
26-Mar-99	1:00	28.0	183	32.7	60	28.43	21.2	1
26-Mar-99	2:00	25.5	181	32.5	59	28.40	20.7	1
26-Mar-99	3:00	22.6	173	31.3	64	28.38	21.0	1
26-Mar-99	4:00	25.1	173	30.9	65	28.35	21.0	1
26-Mar-99	5:00	24.4	174	31.6	64	28.32	21.6	1
26-Mar-99	6:00	21.7	165	31.6	66	28.30	22.3	1
26-Mar-99	7:00	24.8	163	31.8	68	28.28	23.0	13
26-Mar-99	8:00	22.6	170	32.9	67	28.26	23.9	122
26-Mar-99	9:00	21.7	169	35.2	65	28.25	25.7	282
26-Mar-99	10:00	31.1	163	37.6	64	28.22	27.3	435
26-Mar-99	11:00	30.4	154	38.7	64	28.20	28.6	549
26-Mar-99	12:00	31.3	152	40.6	64	28.17	30.2	612
26-Mar-99	13:00	32.7	152	42.3	64	28.14	31.8	622
26-Mar-99	14:00	30.9	154	44.6	62	28.11	32.9	575
26-Mar-99	15:00	32.4	152	46.4	61	28.07	34.0	489
26-Mar-99	16:00	30.4	157	48.2	58	28.05	34.5	372
26-Mar-99	17:00	23.7	156	48.6	58	28.04	34.9	224
26-Mar-99	18:00	25.9	157	47.8	59	28.02	34.3	100
26-Mar-99	19:00	24.6	157	45.7	60	28.00	32.9	16
26-Mar-99	20:00	29.5	161	44.4	60	27.98	32.0	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
26-Mar-99	21:00	35.1	161	43.7	57	27.97	30.4	1
26-Mar-99	22:00	36.5	160	43.2	55	27.94	28.9	1
26-Mar-99	23:00	37.1	163	42.6	55	27.94	28.4	1
27-Mar-99	0:00	36.0	168	42.3	54	27.94	28.0	1
27-Mar-99	1:00	29.8	179	41.2	58	27.97	28.2	1
27-Mar-99	2:00	26.6	195	39.6	63	28.01	28.9	1
27-Mar-99	3:00	15.9	219	38.3	72	28.04	30.9	1
27-Mar-99	4:00	16.3	263	37.6	76	28.05	31.8	1
27-Mar-99	5:00	11.6	251	36.3	81	28.06	32.0	1
27-Mar-99	6:00	9.8	206	35.8	85	28.10	32.2	1
27-Mar-99	7:00	13.9	214	37.2	81	28.13	32.2	2
27-Mar-99	8:00	8.5	210	37.0	81	28.14	32.2	45
27-Mar-99	9:00	11.9	219	39.0	76	28.15	32.7	180
27-Mar-99	10:00	10.1	225	39.7	73	28.18	32.4	198
27-Mar-99	11:00	10.3	237	40.6	70	28.20	32.2	254
27-Mar-99	12:00	10.3	257	41.2	63	28.19	30.6	280
27-Mar-99	13:00	10.3	247	42.8	53	28.19	27.5	391
27-Mar-99	14:00	10.7	212	44.8	42	28.20	24.1	461
27-Mar-99	15:00	10.7	165	46.4	42	28.20	25.0	384
27-Mar-99	16:00	9.8	189	47.1	41	28.21	25.3	363
27-Mar-99	17:00	10.1	162	46.9	38	28.22	23.7	241
27-Mar-99	18:00	8.7	133	44.6	48	28.22	27.1	104
27-Mar-99	19:00	4.7	50	40.3	60	28.22	28.4	14
27-Mar-99	20:00	4.0	39	36.9	73	28.21	30.2	1
27-Mar-99	21:00	4.0	6	36.1	73	28.22	29.5	1
27-Mar-99	22:00	4.3	31	33.8	83	28.22	30.4	1
27-Mar-99	23:00	8.9	43	32.5	85	28.20	29.7	1
28-Mar-99	0:00	4.0	54	32.5	85	28.20	29.5	1
28-Mar-99	1:00	6.9	351	32.0	86	28.17	29.1	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
28-Mar-99	2:00	8.1	303	31.8	86	28.15	28.8	1
28-Mar-99	3:00	8.7	333	32.5	81	28.15	28.4	1
28-Mar-99	4:00	20.6	322	34.5	74	28.16	28.0	1
28-Mar-99	5:00	9.8	34	36.0	70	28.14	28.2	1
28-Mar-99	6:00	12.5	329	34.0	77	28.16	28.6	1
28-Mar-99	7:00	8.3	299	33.6	76	28.17	27.9	3
28-Mar-99	8:00	13.2	246	34.2	76	28.19	28.4	71
28-Mar-99	9:00	13.4	238	35.4	77	28.19	29.8	223
28-Mar-99	10:00	11.2	257	37.0	71	28.20	29.7	366
28-Mar-99	11:00	12.8	258	36.9	71	28.22	29.3	440
28-Mar-99	12:00	19.2	259	38.1	70	28.23	30.4	616
28-Mar-99	13:00	32.0	278	37.6	69	28.25	29.3	461
28-Mar-99	14:00	31.5	298	33.3	86	28.25	30.4	112
28-Mar-99	15:00	18.6	311	36.9	75	28.26	30.7	355
28-Mar-99	16:00	14.1	287	38.1	68	28.27	29.3	220
28-Mar-99	17:00	17.4	278	38.1	69	28.29	29.7	137
28-Mar-99	18:00	18.1	299	35.4	73	28.31	28.4	37
28-Mar-99	19:00	8.7	285	34.2	78	28.33	29.1	12
28-Mar-99	20:00	11.6	258	33.4	80	28.35	28.8	1
28-Mar-99	21:00	10.5	253	33.3	76	28.38	27.5	1
28-Mar-99	22:00	14.1	258	33.4	73	28.40	26.8	1
28-Mar-99	23:00	18.6	264	33.4	72	28.41	26.2	1
29-Mar-99	0:00	16.1	270	32.5	73	28.43	25.9	1
29-Mar-99	1:00	14.1	263	31.6	77	28.44	26.1	1
29-Mar-99	2:00	14.5	259	31.1	78	28.45	25.9	1
29-Mar-99	3:00	12.5	269	30.2	80	28.45	25.3	1
29-Mar-99	4:00	9.6	255	28.9	81	28.46	24.6	1
29-Mar-99	5:00	7.2	260	27.1	84	28.47	23.7	1
29-Mar-99	6:00	4.0	47	26.1	86	28.47	23.4	1

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
29-Mar-99	7:00	7.8	228	27.5	82	28.48	23.2	29
29-Mar-99	8:00	12.5	221	30.4	75	28.48	24.1	153
29-Mar-99	9:00	11.0	227	34.2	63	28.47	23.5	281
29-Mar-99	10:00	14.3	223	37.9	54	28.47	23.7	443
29-Mar-99	11:00	16.3	230	41.0	47	28.46	23.2	529
29-Mar-99	12:00	15.0	234	43.7	41	28.45	22.1	606
29-Mar-99	13:00	19.2	240	45.3	39	28.44	22.8	618
29-Mar-99	14:00	18.3	241	46.9	37	28.43	22.8	577
29-Mar-99	15:00	20.8	258	47.7	32	28.42	19.8	498
29-Mar-99	16:00	17.2	290	45.3	43	28.43	25.0	388
29-Mar-99	17:00	16.3	314	44.8	48	28.43	27.1	249
29-Mar-99	18:00	13.9	318	43.3	50	28.44	27.1	110
29-Mar-99	19:00	9.6	351	40.3	58	28.44	27.5	18
29-Mar-99	20:00	2.2	21	36.0	71	28.42	28.4	1
29-Mar-99	21:00	6.3	60	32.4	81	28.42	28.0	1
29-Mar-99	22:00	6.5	69	31.1	76	28.42	25.0	1
29-Mar-99	23:00	8.1	136	29.8	78	28.40	24.3	1
30-Mar-99	0:00	7.6	103	29.7	75	28.38	23.5	1
30-Mar-99	1:00	10.7	122	29.3	77	28.37	23.7	1
30-Mar-99	2:00	12.5	133	31.3	69	28.35	22.6	1
30-Mar-99	3:00	14.1	117	32.0	63	28.34	21.7	1
30-Mar-99	4:00	15.0	121	32.5	60	28.29	21.2	1
30-Mar-99	5:00	15.9	122	32.0	63	28.25	21.6	1
30-Mar-99	6:00	17.0	116	31.6	64	28.23	21.4	1
30-Mar-99	7:00	17.0	119	32.2	63	28.20	21.7	15
30-Mar-99	8:00	17.7	119	34.5	65	28.15	24.8	119
30-Mar-99	9:00	18.8	128	36.7	63	28.13	26.2	230
30-Mar-99	10:00	16.6	133	38.7	62	28.09	27.7	327
30-Mar-99	11:00	17.0	139	40.6	62	28.08	29.5	365

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
30-Mar-99	12:00	13.4	136	42.3	63	28.05	31.6	357
30-Mar-99	13:00	11.9	125	44.1	61	28.03	32.2	397
30-Mar-99	14:00	12.3	128	46.0	61	28.02	33.4	411
30-Mar-99	15:00	6.9	58	49.8	56	28.02	34.9	417
30-Mar-99	16:00	6.0	346	52.0	52	28.01	35.2	356
30-Mar-99	17:00	8.7	5	51.1	58	28.00	36.9	210
30-Mar-99	18:00	10.7	1	47.3	70	27.99	38.3	96
30-Mar-99	19:00	8.7	354	42.8	82	27.99	37.9	17
30-Mar-99	20:00	9.4	334	38.7	84	28.00	34.7	1
30-Mar-99	21:00	8.7	327	36.1	85	28.00	32.5	1
30-Mar-99	22:00	11.6	349	35.6	86	27.98	32.4	1
30-Mar-99	23:00	8.9	355	34.9	88	27.97	32.2	1
31-Mar-99	0:00	11.0	342	34.3	89	27.98	32.0	1
31-Mar-99	1:00	11.9	332	34.7	86	27.99	32.0	1
31-Mar-99	2:00	11.6	354	33.4	88	27.98	31.3	1
31-Mar-99	3:00	13.0	349	32.0	90	27.97	30.6	1
31-Mar-99	4:00	11.6	354	32.0	88	28.00	29.8	1
31-Mar-99	5:00	13.6	26	31.8	86	27.98	28.9	1
31-Mar-99	6:00	15.4	345	31.3	86	27.99	28.2	1
31-Mar-99	7:00	18.6	6	30.6	84	27.99	27.3	18
31-Mar-99	8:00	20.4	10	31.1	82	28.02	27.0	104
31-Mar-99	9:00	21.5	10	32.4	79	28.04	27.3	266
31-Mar-99	10:00	25.7	14	33.6	76	28.06	27.9	423
31-Mar-99	11:00	23.9	7	35.6	75	28.10	29.3	566
31-Mar-99	12:00	23.0	17	37.2	72	28.11	30.0	636
31-Mar-99	13:00	23.7	26	39.4	70	28.11	31.5	640
31-Mar-99	14:00	21.5	24	41.0	69	28.13	32.0	588
31-Mar-99	15:00	23.0	18	42.3	67	28.14	32.5	532
31-Mar-99	16:00	26.4	23	42.4	68	28.12	32.9	404

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

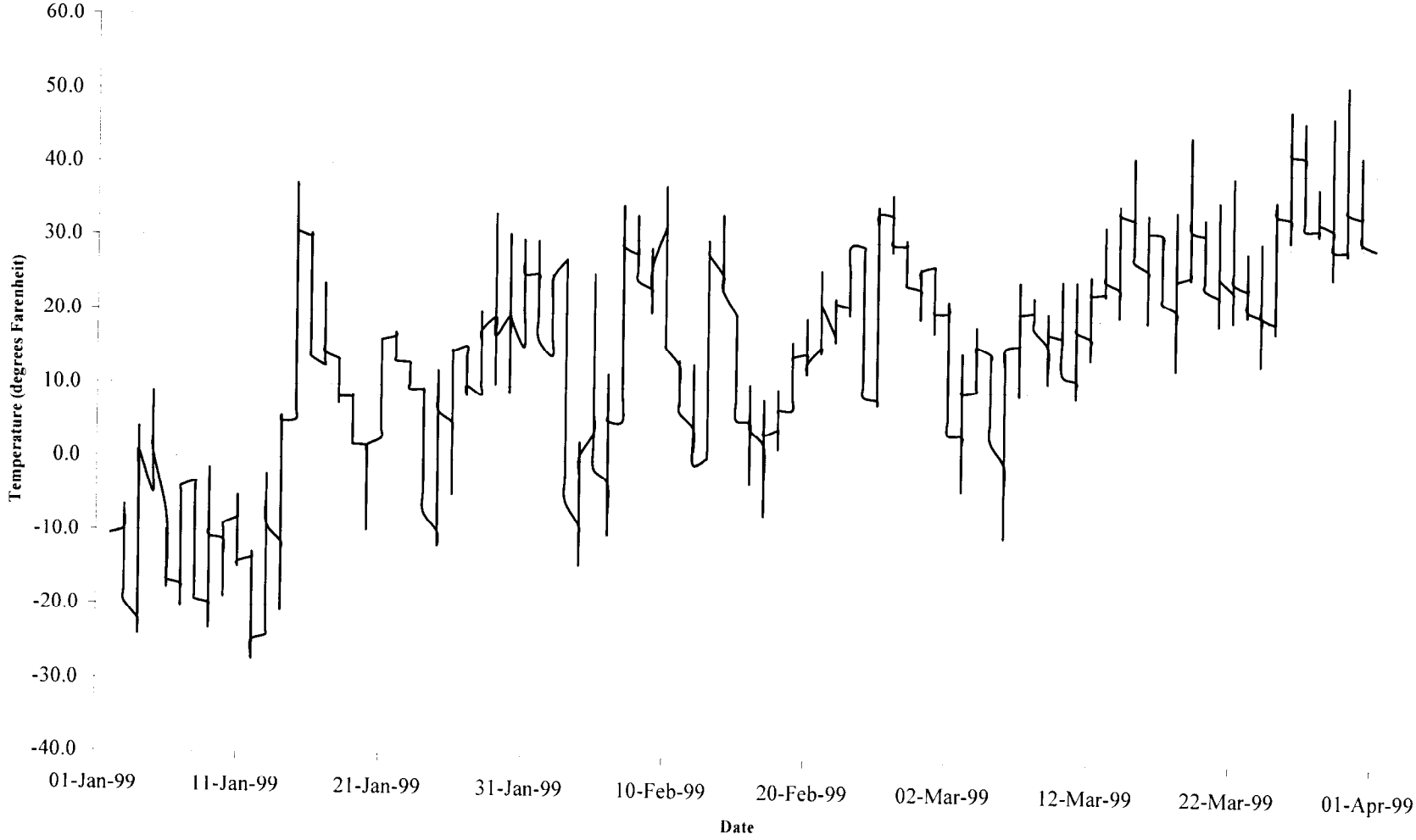
Weather Data Summary
Devils Lake Freeze-Thaw Demonstration

Date	Time	Wind Speed (mph)	Wind Direction (degrees)	Temperature (degrees F)	Relative Humidity (%)	Barometric Pressure (inches Hg)	Dew Point (degrees F)	Solar Radiation (w/m^2)
31-Mar-99	18:00	21.9	34	39.0	73	28.17	32.0	59
31-Mar-99	19:00	20.8	21	36.7	78	28.17	31.5	6
31-Mar-99	20:00	22.1	7	35.1	80	28.20	30.6	1
31-Mar-99	21:00	22.1	13	33.8	80	28.24	29.3	1
31-Mar-99	22:00	24.2	23	32.2	80	28.26	27.7	1
31-Mar-99	23:00	26.4	23	30.9	84	28.27	27.5	1
01-Apr-99	0:00	19.7	29	30.0	87	28.26	27.3	1
Maximum		40.3		52.0	95.0	28.92	38.3	658
Minimum		0.0		-27.2	32.0	27.61	-33.3	1
Average		13.4		16.9	78.0	28.40	11.8	109

Notes:

mph = miles per hour
degrees = 0-360
degrees F = degrees Farenheit
% = percent
inches Hg = inches of mercury
w/m^2 = watts per square meter

Devils Lake Freeze-Thaw Demonstration
Ambient Temperature
(January 2, 1999 - April 1, 1999)



APPENDIX F

FT DEMONSTRATION PRECIPITATE ANALYTICAL RESULTS

Final Results

October 6, 1998

Set Number: 49750
Fund#: 5268
PI: Richard Shockey
Contact Person: Richard Shockey

Request Date: Monday, September 28, 1998
Due Date: Monday, October 12, 1998
Set Description: Simulation Samples

Sample **49750-01**

49750-01	**Brine**	
Total Dissolved Solids		25300 mg/L
49750-02	**Feed**	
Total Dissolved Solids		1490 mg/L
49750-03	**intemediate**	
Total Dissolved Solids		2190 mg/L
49750-04	**treated**	
Total Dissolved Solids		330 mg/L

1 Distribution GS Date 10-6-98

Final Results

June 7, 1999

Set Number: 49834
Fund#: 4365
PI: Brad Stevens
Contact Person: Brad Stevens

Request Date: Thursday, May 20, 1999
Due Date: Thursday, June 03, 1999
Set Description: Devils Lake Freeze Thaw Solid

Sample 49834-01

49834-01 Devils Lake Freeze Thaw Solid

Aluminum	1600 µg/g
Barium	150 µg/g
Calcium	359000 µg/g
Chloride	< 200 µg/g
Iron	880 µg/g
Magnesium	1640 µg/g
Phosphorus	< 400 µg/g
Potassium	< 1000 µg/g
Silicon	9410 µg/g
Sodium	< 1000 µg/g
Sulfate	< 200 µg/g

Distribution AMC Date 6/7/99

ENERGY & ENVIRONMENTAL RESEARCH CENTER
NATURAL MATERIALS ANALYTICAL RESEARCH LAB
X-RAY POWDER DIFFRACTION REPORT

P.I.: Shockey **DATE:** 04/29/99 **Fund #:** 4365 **Sample #:** 990364

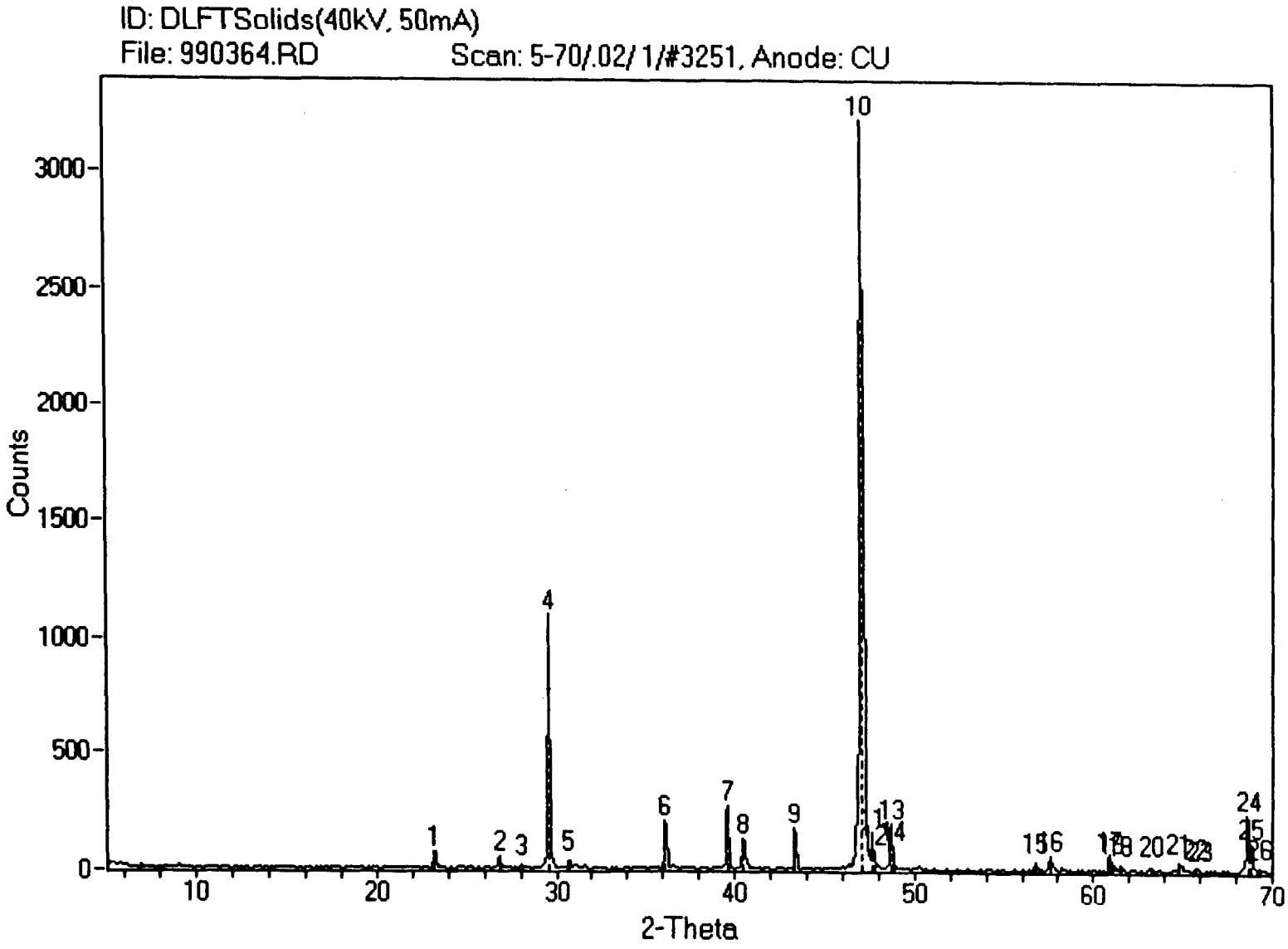
SAMPLE DESCRIPTION: Devils Lake Freeze Thaw Solids

MAJOR PHASE(S):	**NOMINAL COMPOSITION(S):**
Calcite	$CaCO_3$

MINOR PHASE(S):	**NOMINAL COMPOSITION(S):**
Quartz	SiO_2
Dolomite	$CaMg(CO_3)_2$

COMMENTS: Platinum/Rhodium content is due to sample holder interference.
(See attached sheets)

ANALYZED BY: John Kay


ID: DLFTSolids(40kV, 50mA)
File: 990364.RD
Scan: 5-70/.02/ 1/#3251, Anode: CU
Counts
3000
2500
2000
1500
1000
500
0
10
20
30
40
50
60
70
2-Theta

UND EERC

Jade: Peak Listing — Fri Apr 30 1999 @11:34a

File: 990364.RD> DLFTSolids(40kV, 50mA)

Scan Parameters:

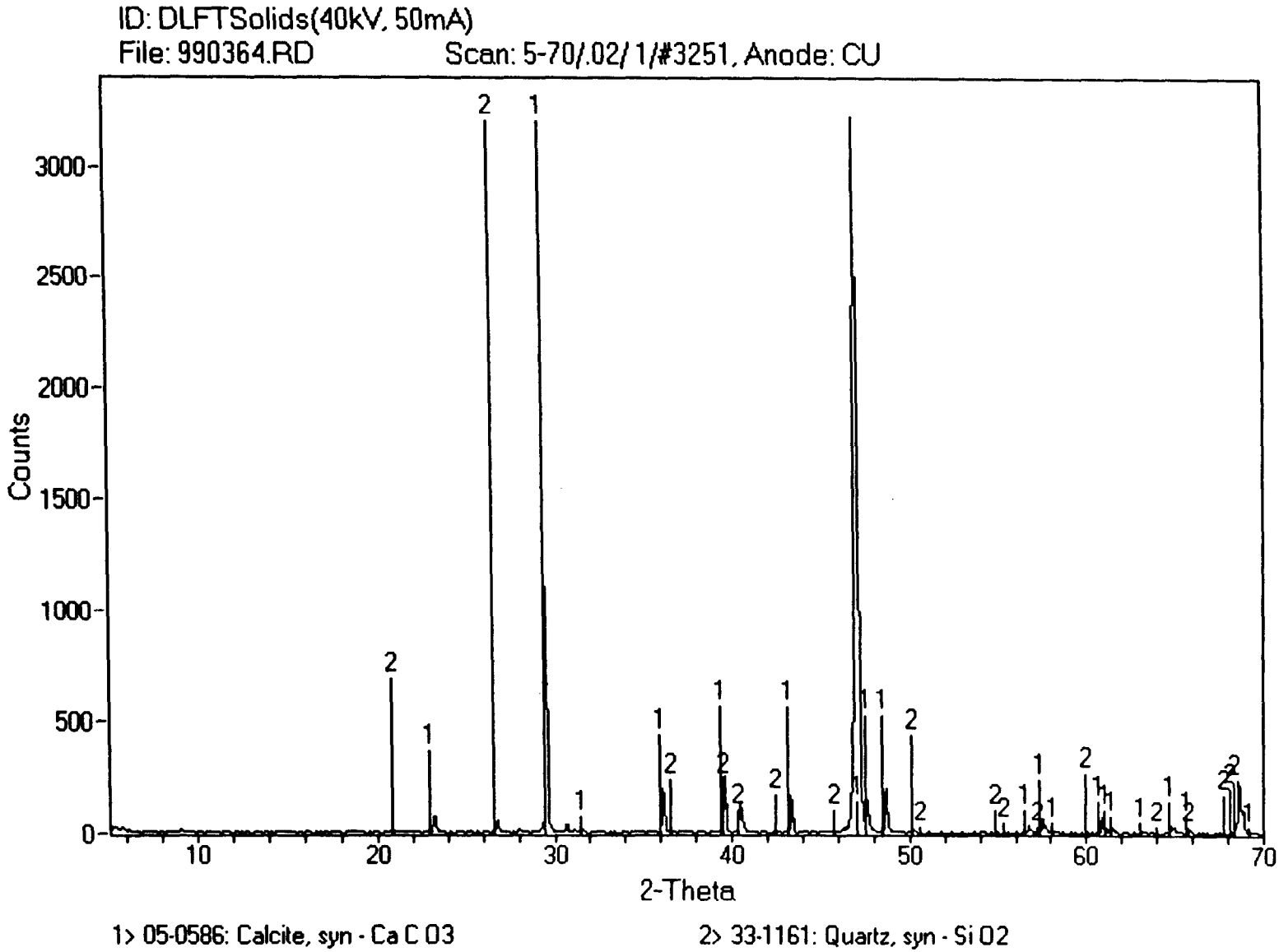
Radiation = CU_1.54059
Scan Range = 5- 70
Step Size = .02
Count Time = 1 sec.

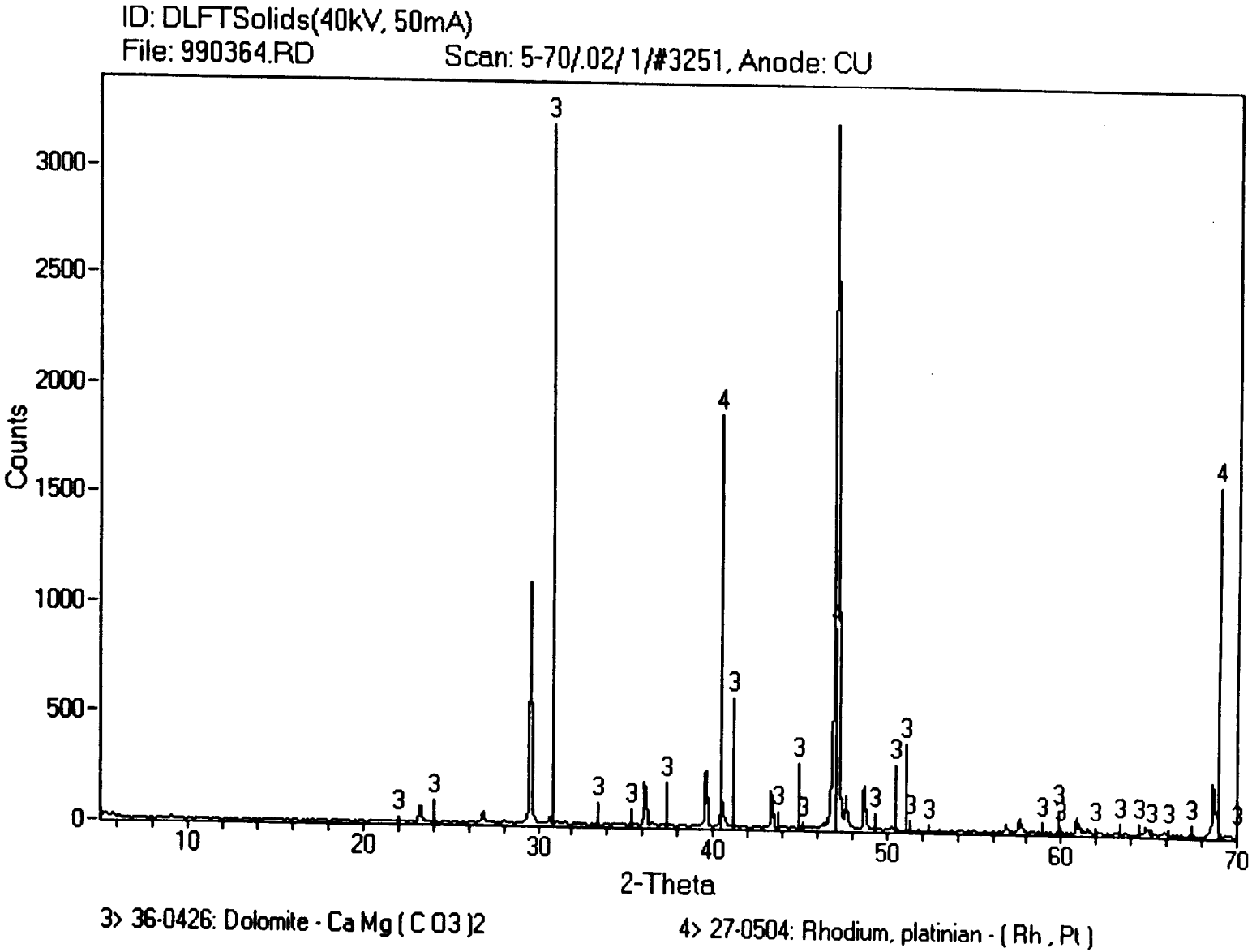
Search Parameters:

Filter length(pts) = 11
Noise level(sigmas) = 3.5
Intensity cutoff(%) = 1.5-100
2-Theta Zero (degs) = 0

	Peak-Position		Centroid-Position		Peak & Area are without Bkgrd					
#	2Theta	d	2Theta	d	Bkgrd	Peak	I%	Area	I%	FWHM*
1:	23.238	3.8247	23.231	3.8258	5	74	2.3	13	1.6	0.158
2:	26.818	3.3217	26.804	3.3233	6	50	1.6	8	1.0	0.144
3:	28.037	3.1799	28.032	3.1805	6	13	0.4	1	0.1	0.069
4:	29.580	3.0175	29.582	3.0173	7	1095	34.0	152	18.7	0.125
5:	30.678	2.9119	30.683	2.9115	5	35	1.1	5	0.6	0.129
6:	36.125	2.4844	36.141	2.4833	3	201	6.2	31	3.8	0.139
7:	39.579	2.2752	39.579	2.2752	3	263	8.2	35	4.3	0.120
8:	40.479	2.2267	40.489	2.2261	6	129	4.0	29	3.6	0.202
9:	43.326	2.0867	43.329	2.0866	4	173	5.4	19	2.3	0.099
10:	47.079	1.9287	47.082	1.9286	6	3220	100.0	812	100.0	0.227
11:	47.659	1.9066	47.664	1.9064	6	150	4.7	23	2.8	0.138
12:	47.780	1.9021	47.780	1.9021	5	80	2.5	12	1.5	0.135x
13:	48.680	1.8690	48.697	1.8684	7	192	6.0	30	3.7	0.141
14:	48.815	1.8641	48.800	1.8647	7	91	2.8	12	1.5	0.119x
15:	56.723	1.6216	56.736	1.6212	3	35	1.1	4	0.5	0.103
16:	57.560	1.6000	57.560	1.6000	2	64	2.0	9	1.1	0.127
17:	60.844	1.5212	60.840	1.5213	2	60	1.9	8	1.0	0.120
18:	61.015	1.5174	61.012	1.5174	2	39	1.2	6	0.7	0.138
19:	61.539	1.5057	61.540	1.5057	2	28	0.9	3	0.4	0.096
20:	63.217	1.4697	63.220	1.4697	4	22	0.7	2	0.2	0.082
21:	64.820	1.4372	64.829	1.4370	4	37	1.1	5	0.6	0.122
22:	65.738	1.4193	65.740	1.4193	3	18	0.6	1	0.1	0.050
23:	65.978	1.4147	65.983	1.4146	2	7	0.2	1	0.1	0.129
24:	68.641	1.3662	68.650	1.3661	4	242	7.5	49	6.0	0.182
25:	68.857	1.3624	68.851	1.3626	4	115	3.6	19	2.3	0.149x
26:	69.329	1.3543	69.333	1.3542	4	18	0.6	3	0.4	0.150

* Intensity values are based on total raw counts.
x Likely K-alpha2 peaks.


ID: DLFTSolids(40kV, 50mA)
File: 990364.RD
Scan: 5-70/.02/ 1/#3251, Anode: CU
Counts
2-Theta
1> 05-0586: Calcite, syn - Ca C O3
2> 33-1161: Quartz, syn - Si O2


ID: DLFTSolids(40kV, 50mA)
File: 990364.RD
Scan: 5-70/.02/ 1/#3251, Anode: CU
Counts
2-Theta
3> 36-0426: Dolomite - Ca Mg (C O3)2
4> 27-0504: Rhodium, platinian - (Rh , Pt)

ENERGY AND ENVIRONMENTAL RESEARCH CENTER
UNIVERSITY OF NORTH DAKOTA
WDXRF ANALYSIS REPORT

Date: 25-May-99

Fund Number: 4365

Sample Number: 990364

Coal Laboratory Number:

Sample Description: Devils Lake Freeze Thaw Solids

Sample Submitter: R. Shokey

Analyst: Carolyn Lillemoen

Oxides (wt.%)	(a)	(b)	(c)	Elemental (wt.%)	(d)	(e)
SiO2	3.1	7.1	7.1	Si	4.8	4.8
Al2O3	0.2	0.5	0.5	Al	0.3	0.3
Fe2O3	0.0	0.0	0.0	Fe	0.0	0.0
TiO2	0.0	0.0	0.0	Ti	0.0	0.0
P2O5	0.0	0.0	0.0	P	0.0	0.0
CaO	40.3	92.2	92.2	Ca	94.6	94.6
MgO	0.0	0.0	0.0	Mg	0.0	0.0
Na2O	0.0	0.0	0.0	Na	0.0	0.0
K2O	0.1	0.2	0.2	K	0.3	0.3
SO3	0.0	0.0	-----	S	0.0	-----
Total	43.7					

(a) Oxide concentrations (wt.%) on an ash basis.
(b) Oxide concentrations normalized to a closure of 100%.
(c) Oxide concentrations renormalized to a SO3-free basis.
(d) Elemental concentrations (wt.%) on an ash basis.
(e) Elemental concentrations renormalized to a S-free basis.

Comments:
Carbon is not reported in this analysis

LFT solids Sample

$CaCO_3$

Thu Apr 29 08:57:05 1999

Refit _Na-K' _Na-K" _Mg-K' _Mg-K" _Al-K' _Al-K" _P -K' _P -K" _S -K' _S -K" _Cl-
Refit _Si-K" _S -K _Ca-K" _Ti-K
Filter Fit Method
Chi-sqd = 0.78 Livetime = 30.0 Sec.
Standardless Analysis

Element	Relative k-ratio	Error (1-Sigma)	Net Counts	Error (1-Sigma)
Na-K	0.00141	+/- 0.00087	31	+/- 19
Mg-K	0.00355	+/- 0.00101	81	+/- 23
Al-K	0.01011	+/- 0.00126	229	+/- 29
Si-K	0.05263	+/- 0.00186	1163	+/- 41
P -K	0.00302	+/- 0.00144	65	+/- 31
S -K	0.00000	+/- 0.00001	0	+/- 0
Cl-K	0.00000	+/- 0.00001	1	+/- 5
K -K	0.01185	+/- 0.00229	150	+/- 29
Ca-K	0.52850	+/- 0.00733	5839	+/- 81
Ti-K	0.00000	+/- 0.00001	0	+/- 0
Cr-K	0.00521	+/- 0.00302	32	+/- 19
Fe-K	0.01909	+/- 0.00514	78	+/- 21
Ba-L	0.00752	+/- 0.00464	48	+/- 29
O -K	0.22500	+/- 0.00568	2459	+/- 62
C -K	0.13211	+/- 0.00481	1125	+/- 41

Adjustment Factors	K	L	M
Z-Balance:	0.00000	0.00000	0.00000
Shell:	1.00000	1.00000	1.00000

ZAF Correction Acc.Volt.= 15 kV Take-off Angle=43.37 deg
Number of Iterations = 6

Element	k-ratio (calc.)	ZAF	Atom %	Element Wt %	Wt % Err. (1-Sigma)	No. of Cations
Na-K	0.0008	2.195	0.14	0.17	+/- 0.10	0.059
Mg-K	0.0019	1.651	0.25	0.32	+/- 0.09	0.106
Al-K	0.0055	1.436	0.57	0.79	+/- 0.10	0.236
Si-K	0.0285	1.244	2.45	3.54	+/- 0.13	1.024
P -K	0.0016	1.220	0.13	0.20	+/- 0.10	0.052
S -K	0.0000	1.098	0.00	0.00	+/- 0.00	0.000
Cl-K	0.0000	1.087	0.00	0.00	+/- 0.00	0.000
K -K	0.0064	1.019	0.32	0.65	+/- 0.13	0.136
Ca-K	0.2862	1.062	14.71	30.39	+/- 0.42	6.154
Ti-K	0.0000	1.251	0.00	0.00	+/- 0.00	0.000
Cr-K	0.0028	1.201	0.13	0.34	+/- 0.20	0.053
Fe-K	0.0103	1.193	0.43	1.23	+/- 0.33	0.179
Ba-L	0.0041	1.428	0.08	0.58	+/- 0.36	0.034
O -K	0.1218	3.883	57.39	47.31	+/- 1.19	---
C -K	0.0715	2.024	23.40	14.48	+/- 0.53	9.787
Total			100.00	100.00		17.821

The number of cation results are based upon 24 Oxygen atoms

Thu Apr 29 08:54:35 1999

Refit _Na-K' _Na-K" _Mg-K' _Mg-K" _Al-K' _Al-K" _P -K' _P -K" _S -K' _S -K" _Cl-
Refit _Na-K _Ca-K" _Cr-K _Ba-L _O -K" _C -K'
Refit _C -K"
Filter Fit Method
Chi-sqd = 0.91 Livetime = 30.0 Sec.
Standardless Analysis

Element	Relative k-ratio	Error (1-Sigma)	Net Counts	Error (1-Sigma)
Na-K	0.00000	+/- 0.00001	0	+/- 0
Mg-K	0.00164	+/- 0.00097	42	+/- 25
Al-K	0.00980	+/- 0.00116	250	+/- 30
Si-K	0.03378	+/- 0.00253	841	+/- 63
P -K	0.00425	+/- 0.00128	104	+/- 31
S -K	0.00279	+/- 0.00144	58	+/- 30
Cl-K	0.00000	+/- 0.00001	1	+/- 6
K -K	0.00596	+/- 0.00182	85	+/- 26
Ca-K	0.50541	+/- 0.00675	6287	+/- 84
Ti-K	0.00088	+/- 0.00210	8	+/- 19
Cr-K	0.00000	+/- 0.00001	0	+/- 0
Fe-K	0.00543	+/- 0.00391	25	+/- 18
Ba-L	0.00000	+/- 0.00001	0	+/- 0
O -K	0.28677	+/- 0.00406	3529	+/- 50
C -K	0.14328	+/- 0.00334	1374	+/- 32

Adjustment Factors	K	L	M
Z-Balance:	0.00000	0.00000	0.00000
Shell:	1.00000	1.00000	1.00000

ZAF Correction Acc.Volt.= 15 kV Take-off Angle=43.37 deg
Number of Iterations = 7

Element	k-ratio (calc.)	ZAF	Atom %	Element Wt %	Wt % Err. (1-Sigma)	No. of Cations
Na-K	0.0000	2.134	0.00	0.00	+/- 0.00	0.000
Mg-K	0.0008	1.654	0.11	0.14	+/- 0.08	0.041
Al-K	0.0051	1.435	0.50	0.73	+/- 0.09	0.193
Si-K	0.0175	1.244	1.44	2.17	+/- 0.16	0.553
P -K	0.0022	1.210	0.16	0.27	+/- 0.08	0.061
S -K	0.0014	1.112	0.09	0.16	+/- 0.08	0.036
Cl-K	0.0000	1.085	0.00	0.00	+/- 0.00	0.000
K -K	0.0031	1.022	0.15	0.31	+/- 0.10	0.058
Ca-K	0.2613	1.065	12.92	27.84	+/- 0.37	4.965
Ti-K	0.0005	1.229	0.02	0.06	+/- 0.13	0.008
Cr-K	0.0000	1.210	0.00	0.00	+/- 0.00	0.000
Fe-K	0.0028	1.198	0.11	0.34	+/- 0.24	0.043
Ba-L	0.0000	1.461	0.00	0.00	+/- 0.00	0.000
O -K	0.1483	3.623	62.43	53.73	+/- 0.76	---
C -K	0.0741	1.924	22.07	14.26	+/- 0.33	8.484
Total			100.00	100.00		14.442

The number of cation results are based upon 24 Oxygen atoms

Thu Apr 29 08:52:07 1999

Refit _Na-K' _Na-K" _Mg-K' _Mg-K" _Al-K' _Al-K" _P -K' _P -K" _S -K' _S -K" _Cl-
Refit _Si-K" _K -K _Ca-K" _Ti-K _Fe-K _Ba-L _O -K"
Filter Fit Method
Chi-sqd = 1.02 Livetime = 10.0 Sec.
Standardless Analysis

Element	Relative k-ratio	Error (1-Sigma)	Net Counts	Error (1-Sigma)
Na-K	0.00785	+/- 0.00283	26	+/- 9
Mg-K	0.01720	+/- 0.00332	58	+/- 11
Al-K	0.03217	+/- 0.00435	106	+/- 14
Si-K	0.10754	+/- 0.00623	345	+/- 20
P -K	0.00288	+/- 0.00416	9	+/- 13
S -K	0.00522	+/- 0.00485	15	+/- 14
Cl-K	0.01006	+/- 0.00481	23	+/- 11
K -K	0.00000	+/- 0.00001	0	+/- 0
Ca-K	0.21247	+/- 0.01246	342	+/- 20
Ti-K	0.00000	+/- 0.00001	0	+/- 0
Cr-K	0.00925	+/- 0.00578	8	+/- 5
Fe-K	0.00000	+/- 0.00001	0	+/- 0
Ba-L	0.00000	+/- 0.00001	0	+/- 0
O -K	0.59536	+/- 0.01638	945	+/- 26
C -K	---	---	434	+/- 24

Adjustment Factors	K	L	M
Z-Balance:	0.00000	0.00000	0.00000
Shell:	1.00000	1.00000	1.00000

ZAF Correction Acc.Volt.= 15 kV Take-off Angle=43.37 deg
Number of Iterations = 8

Element	k-ratio (calc.)	ZAF	Atom %	Element Wt %	Wt % Err. (1-Sigma)	No. of Cations
Na-K	0.0045	2.187	0.80	0.99	+/- 0.36	0.230
Mg-K	0.0099	1.657	1.26	1.64	+/- 0.32	0.361
Al-K	0.0185	1.458	1.87	2.70	+/- 0.36	0.535
Si-K	0.0618	1.282	5.27	7.93	+/- 0.46	1.512
P -K	0.0017	1.291	0.13	0.21	+/- 0.31	0.037
S -K	0.0030	1.172	0.21	0.35	+/- 0.33	0.059
Cl-K	0.0058	1.172	0.36	0.68	+/- 0.32	0.102
K -K	0.0000	1.077	0.00	0.00	+/- 0.00	0.000
Ca-K	0.1221	1.081	6.16	13.21	+/- 0.77	1.765
Ti-K	0.0000	1.214	0.00	0.00	+/- 0.00	0.000
Cr-K	0.0053	1.194	0.23	0.63	+/- 0.40	0.065
Fe-K	0.0000	1.187	0.00	0.00	+/- 0.00	0.000
Ba-L	0.0000	1.413	0.00	0.00	+/- 0.00	0.000
O -K	0.3423	2.094	83.72	71.67	+/- 1.97	---
Total			100.00	100.00		4.668

The number of cation results are based upon 24 Oxygen atoms

Thu Apr 29 08:53:11 1999

Refit _Na-K' _Na-K" _Mg-K' _Mg-K" _Al-K' _Al-K" _P -K' _P -K" _S -K' _S -K" _Cl-
Refit _Na-K _Ca-K" _Cr-K _Ba-L _O -K" _C -K'
Refit _C -K"
Filter Fit Method
Chi-sqd = 0.91 Livetime = 30.0 Sec.
Standardless Analysis

Element	Relative k-ratio	Error (1-Sigma)	Net Counts	Error (1-Sigma)
Na-K	0.00000	+/- 0.00001	0	+/- 0
Mg-K	0.00191	+/- 0.00114	42	+/- 25
Al-K	0.01143	+/- 0.00135	250	+/- 30
Si-K	0.03943	+/- 0.00296	841	+/- 63
P -K	0.00496	+/- 0.00149	104	+/- 31
S -K	0.00326	+/- 0.00169	58	+/- 30
Cl-K	0.00000	+/- 0.00001	1	+/- 6
K -K	0.00696	+/- 0.00213	85	+/- 26
Ca-K	0.58993	+/- 0.00788	6287	+/- 84
Ti-K	0.00103	+/- 0.00245	8	+/- 19
Cr-K	0.00000	+/- 0.00001	0	+/- 0
Fe-K	0.00634	+/- 0.00457	25	+/- 18
Ba-L	0.00000	+/- 0.00001	0	+/- 0
O -K	0.33474	+/- 0.00474	3529	+/- 50
C -K	---	---	1374	+/- 32

Adjustment Factors	K	L	M
Z-Balance:	0.00000	0.00000	0.00000
Shell:	1.00000	1.00000	1.00000

ZAF Correction Acc.Volt.= 15 kV Take-off Angle=43.37 deg
Number of Iterations = 8

Element	k-ratio (calc.)	ZAF	Atom %	Element Wt %	Wt % Err. (1-Sigma)	No. of Cations
Na-K	0.0000	2.185	0.00	0.00	+/- 0.00	0.000
Mg-K	0.0010	1.694	0.15	0.17	+/- 0.10	0.045
Al-K	0.0062	1.459	0.69	0.90	+/- 0.11	0.210
Si-K	0.0213	1.258	1.97	2.68	+/- 0.20	0.600
P -K	0.0027	1.221	0.22	0.33	+/- 0.10	0.066
S -K	0.0018	1.116	0.13	0.20	+/- 0.10	0.039
Cl-K	0.0000	1.080	0.00	0.00	+/- 0.00	0.000
K -K	0.0038	1.011	0.20	0.38	+/- 0.12	0.061
Ca-K	0.3186	1.060	17.44	33.78	+/- 0.45	5.297
Ti-K	0.0006	1.233	0.03	0.07	+/- 0.16	0.009
Cr-K	0.0000	1.206	0.00	0.00	+/- 0.00	0.000
Fe-K	0.0034	1.190	0.15	0.41	+/- 0.29	0.046
Ba-L	0.0000	1.465	0.00	0.00	+/- 0.00	0.000
O -K	0.1808	3.379	79.02	61.09	+/- 0.87	---
Total			100.00	100.00		6.373

The number of cation results are based upon 24 Oxygen atoms

North Dakota Department of Health
Chemistry Division

Original Report Date: 10/ 6/98 Report Date: 10/ 6/98

Log Number: 98-C2739

Date Collected: 9/21/98 Date Received: 9/23/98
Time Collected: 16:00 Time Received: 14:48
Township: Range:
Section: Owner:
Source: BRINE
Project: RNDLS DEVILS LAKE SIMULATION- C9803
Comments:

RICHARD SHOCKEY
ATTN: UND EERC
PO BOX 9018
GRAND FORKS ND 58202-9018

Approved by: _____

Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	24900	umhos/cm	
Dissolved Solids(C)-Total	24000	mg/L	Very High
Hardness Total (as CaCO3)	7120	mg/L	Very High
Alkalinity (CaCO3)(Total)	2760	mg/L	Very High
pH	9.04		
Iron (Fe)	< 0.007	mg/L	Satisfactory
Manganese (Mn)	< 0.002	mg/L	Satisfactory
Calcium (Ca)	47.8	mg/L	
Magnesium (Mg)	1700	mg/L	
Sodium (Na)	5360	mg/L	Very High
Potassium (K)	968.	mg/L	
Carbonate (CO3)	707.	mg/L	
Bicarbonate (HCO3)	1930	mg/L	
Sulfate as (SO4)	11500	mg/L	Very High
Chloride	2800	mg/L	Very High
Nitrate + Nitrite (N)	0.27	mg/L	Satisfactory
Silica (SiO2)	17.8	mg/L	
Ammonia (N)	1.04	mg/L	
Hydroxide (OH)	< 1	mg/L	
Phosphorus (Total) (P)	0.625	mg/L	
Chemical Oxygen Demand	755.	mg/L	
Hardness (Total)	416.	gr/gal	
Turbidity	16.0	NTU	
Percent Sodium	58.1	%	
Sodium Adsorption Ratio	27.6		

This water may prove harmful to individuals on sodium-restricted diets. Please consult your family doctor.

Log Number: 98-C2739 cont'd

This water may exert a laxative effect upon persons unaccustomed to its high sulfate content.

This water is classified C4-S4 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is 2.31
This indicates a stable, non-corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Chemistry Division, Box 937, Bismarck, ND 58502-0937 (701) 328-6140.

North Dakota Department of Health
Chemistry Division

Original Report Date: 10/ 6/98 Report Date: 10/ 6/98

Log Number: 98-C2740

Date Collected: 9/21/98 Date Received: 9/23/98
Time Collected: 14:15 Time Received: 14:48
Township: Range:
Section: Owner:
Source: INTERMEDIATE COMPOSITE 1
Project: RNDLS DEVILS LAKE SIMULATION- C9803
Comments:

RICHARD SHOCKEY
ATTN: UND EERC
PO BOX 9018
GRAND FORKS ND 58202-9018

Approved by: _____

Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	2960	umhos/cm	
Dissolved Solids(C)-Total	2010	mg/L	High
Hardness Total (as CaCO3)	552.	mg/L	Very High
Alkalinity (CaCO3)(Total)	297.	mg/L	Satisfactory
pH	8.85		
Iron (Fe)	< 0.007	mg/L	Satisfactory
Manganese (Mn)	< 0.002	mg/L	Satisfactory
Calcium (Ca)	28.4	mg/L	
Magnesium (Mg)	117.	mg/L	
Sodium (Na)	415.	mg/L	Very High
Potassium (K)	53.6	mg/L	
Carbonate (CO3)	29.	mg/L	
Bicarbonate (HCO3)	304.	mg/L	
Sulfate as (SO4)	1040	mg/L	Very High
Chloride	172.	mg/L	High
Nitrate + Nitrite (N)	0.04	mg/L	Satisfactory
Silica (SiO2)	5.87	mg/L	
Ammonia (N)	0.160	mg/L	
Hydroxide (OH)	< 1	mg/L	
Phosphorus (Total) (P)	< 0.018	mg/L	
Chemical Oxygen Demand	21.	mg/L	
Hardness (Total)	32.	gr/gal	
Suspended Solids (Total)	< 5	mg/L	
Turbidity	5.10	NTU	
Percent Sodium	59.1	%	
Sodium Adsorption Ratio	7.68		

Log Number: 98-C2740 cont'd

This water may prove harmful to individuals on sodium-restricted diets. Please consult your family doctor.

This water may exert a laxative effect upon persons unaccustomed to its high sulfate content.

This water is classified C4-S2 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is 0.92
This indicates a stable, non-corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Chemistry Division, Box 937, Bismarck, ND 58502-0937 (701) 328-6140.

North Dakota Department of Health
Chemistry Division

Original Report Date: 10/ 6/98 Report Date: 10/ 6/98

Log Number: 98-C2741

Date Collected: 9/21/98 Date Received: 9/23/98
Time Collected: 14:15 Time Received: 14:48
Township: Range:
Section: Owner:
Source: INTERMEDIATE COMPOSITE 2
Project: RNDLS DEVILS LAKE SIMULATION- C9803
Comments:

RICHARD SHOCKEY
ATTN: UND EERC
PO BOX 9018
GRAND FORKS ND 58202-9018

Approved by: _____

Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	2960	umhos/cm	
Dissolved Solids(C)-Total	2030	mg/L	High
Hardness Total (as CaCO3)	576.	mg/L	Very High
Alkalinity (CaCO3)(Total)	300.	mg/L	Satisfactory
pH	8.83		
Iron (Fe)	< 0.007	mg/L	Satisfactory
Manganese (Mn)	< 0.002	mg/L	Satisfactory
Calcium (Ca)	29.4	mg/L	
Magnesium (Mg)	122.	mg/L	
Sodium (Na)	432.	mg/L	Very High
Potassium (K)	55.6	mg/L	
Carbonate (CO3)	29.	mg/L	
Bicarbonate (HCO3)	307.	mg/L	
Sulfate as (SO4)	1040	mg/L	Very High
Chloride	169.	mg/L	High
Nitrate + Nitrite (N)	0.05	mg/L	Satisfactory
Silica (SiO2)	6.15	mg/L	
Ammonia (N)	0.143	mg/L	
Hydroxide (OH)	< 1	mg/L	
Phosphorus (Total) (P)	0.052	mg/L	
Chemical Oxygen Demand	129.	mg/L	
Hardness (Total)	34.	gr/gal	
Suspended Solids (Total)	< 5	mg/L	
Turbidity	7.70	NTU	
Percent Sodium	59.1	%	
Sodium Adsorption Ratio	7.83		

Original Report Date: 10/ 6/98

Report Date: 10/ 6/98

Log Number: 98-C2741 cont'd

This water may prove harmful to individuals on sodium-restricted diets. Please consult your family doctor.

This water may exert a laxative effect upon persons unaccustomed to its high sulfate content.

This water is classified C4-S2 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is 0.92
This indicates a stable, non-corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Chemistry Division, Box 937, Bismarck, ND 58502-0937 (701) 328-6140.

North Dakota Department of Health
Chemistry Division

Original Report Date: 10/ 7/98 Report Date: 10/ 7/98

Log Number: 98-C2742

Date Collected: 9/21/98 Date Received: 9/23/98
Time Collected: 15:00 Time Received: 14:48
Township: Range:
Section: Owner:
Source: TREATED WATER COMPOSITE 1
Project: RNDLS DEVILS LAKE SIMULATION- C9803
Comments:

RICHARD SHOCKEY
ATTN: UND EERC
PO BOX 9018
GRAND FORKS ND 58202-9018

Approved by: _____

Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	545.	umhos/cm	
Dissolved Solids(C)-Total	310.	mg/L	Fairly Low
Hardness Total (as CaCO3)	132.	mg/L	Fairly Low
Alkalinity (CaCO3)(Total)	111.	mg/L	Fairly Low
pH	7.37		
Iron (Fe)	< 0.007	mg/L	Satisfactory
Manganese (Mn)	< 0.002	mg/L	Satisfactory
Calcium (Ca)	26.9	mg/L	
Magnesium (Mg)	15.8	mg/L	
Sodium (Na)	47.6	mg/L	Fairly Low
Potassium (K)	7.5	mg/L	
Carbonate (CO3)	< 1	mg/L	
Bicarbonate (HCO3)	135.	mg/L	
Sulfate as (SO4)	119.	mg/L	Fairly Low
Chloride	24.7	mg/L	Low
Nitrate + Nitrite (N)	0.02	mg/L	Satisfactory
Silica (SiO2)	2.06	mg/L	
Fluoride (F) (IC)	0.060	mg/L	
Ammonia (N)	0.089	mg/L	
Hydroxide (OH)	< 1	mg/L	
Phosphorus (Total) (P)	0.068	mg/L	
Chemical Oxygen Demand	12.	mg/L	
Hardness (Total)	8.	gr/gal	
Suspended Solids (Total)	< 5	mg/L	
Turbidity	1.70	NTU	
Percent Sodium	42.1	%	
Sodium Adsorption Ratio	1.80		

Log Number: 98-C2742 cont'd

This water is classified C2-S1 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is -0.94
This may indicate a potentially corrosive water.

Statement: This analysis includes chemical content only,
and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Chemistry Division, Box 937, Bismarck, ND 58502-0937 (701) 328-6140.

North Dakota Department of Health
Chemistry Division

Original Report Date: 10/ 7/98 Report Date: 10/ 7/98

Log Number: 98-C2743

Date Collected: 9/21/98 Date Received: 9/23/98
Time Collected: 15:00 Time Received: 14:48
Township: Range:
Section: Owner:
Source: TREATED WATER COMPOSITE 2
Project: RNDLS DEVILS LAKE SIMULATION- C9803
Comments:

RICHARD SHOCKEY
ATTN: UND EERC
PO BOX 9018
GRAND FORKS ND 58202-9018

Approved by: _____

Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	543.	umhos/cm	
Dissolved Solids(C)-Total	315.	mg/L	Fairly Low
Hardness Total (as CaCO3)	141.	mg/L	Fairly Low
Alkalinity (CaCO3)(Total)	108.	mg/L	Fairly Low
pH	7.43		
Iron (Fe)	< 0.007	mg/L	Satisfactory
Manganese (Mn)	< 0.002	mg/L	Satisfactory
Calcium (Ca)	28.7	mg/L	
Magnesium (Mg)	16.8	mg/L	
Sodium (Na)	50.6	mg/L	Fairly Low
Potassium (K)	7.9	mg/L	
Carbonate (CO3)	< 1	mg/L	
Bicarbonate (HCO3)	132.	mg/L	
Sulfate as (SO4)	119.	mg/L	Fairly Low
Chloride	24.7	mg/L	Low
Nitrate + Nitrite (N)	0.02	mg/L	Satisfactory
Silica (SiO2)	2.19	mg/L	
Fluoride (F) (IC)	0.060	mg/L	
Ammonia (N)	0.085	mg/L	
Hydroxide (OH)	< 1	mg/L	
Phosphorus (Total) (P)	0.210	mg/L	
Chemical Oxygen Demand	8.	mg/L	
Hardness (Total)	8.	gr/gal	
Suspended Solids (Total)	< 5	mg/L	
Turbidity	1.70	NTU	
Percent Sodium	42.0	%	
Sodium Adsorption Ratio	1.85		

Original Report Date: 10/ 7/98

Report Date: 10/ 7/98

Log Number: 98-C2743 cont'd

This water is classified C2-S1 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is -0.86
This may indicate a potentially corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Chemistry Division, Box 937, Bismarck, ND 58502-0937 (701) 328-6140.

North Dakota Department of Health
Chemistry Division

Original Report Date: 10/ 7/98 Report Date: 10/ 7/98

Log Number: 98-C2744

Date Collected: 9/21/98 Date Received: 9/23/98
Time Collected: 15:30 Time Received: 14:48
Township: Range:
Section: Owner:
Source: FEED 1
Project: RNDLS DEVILS LAKE SIMULATION- C9803
Comments:

RICHARD SHOCKEY
ATTN: UND EERC
PO BOX 9018
GRAND FORKS ND 58202-9018

Approved by: _____

Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	2130	umhos/cm	
Dissolved Solids(C)-Total	1430	mg/L	Average
Hardness Total (as CaCO3)	524.	mg/L	Very High
Alkalinity (CaCO3)(Total)	326.	mg/L	Satisfactory
pH	8.00		
Iron (Fe)	< 0.007	mg/L	Satisfactory
Manganese (Mn)	< 0.002	mg/L	Satisfactory
Calcium (Ca)	73.5	mg/L	
Magnesium (Mg)	82.7	mg/L	
Sodium (Na)	283.	mg/L	Very High
Potassium (K)	42.9	mg/L	
Carbonate (CO3)	< 1	mg/L	
Bicarbonate (HCO3)	398.	mg/L	
Sulfate as (SO4)	626.	mg/L	Very High
Chloride	124.	mg/L	Average
Nitrate + Nitrite (N)	0.35	mg/L	Satisfactory
Silica (SiO2)	5.04	mg/L	
Fluoride (F) (IC)	0.140	mg/L	
Ammonia (N)	0.077	mg/L	
Hydroxide (OH)	< 1	mg/L	
Phosphorus (Total) (P)	0.156	mg/L	
Chemical Oxygen Demand	24.	mg/L	
Hardness (Total)	31.	gr/gal	
Suspended Solids (Total)	< 5	mg/L	
Turbidity	2.00	NTU	
Percent Sodium	51.4	%	
Sodium Adsorption Ratio	5.37		

This water may prove harmful to individuals on sodium-restricted diets. Please consult your family doctor.

This water may exert a laxative effect upon persons unaccustomed to its high sulfate content.

This water is classified C3-S2 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is 0.53
This indicates a stable, non-corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Chemistry Division, Box 937, Bismarck, ND 58502-0937 (701) 328-6140.

North Dakota Department of Health
Chemistry Division

Original Report Date: 10/ 7/98 Report Date: 10/ 7/98

Log Number: 98-C2745

Date Collected: 9/21/98 Date Received: 9/23/98
Time Collected: 15:30 Time Received: 14:48
Township: Range:
Section: Owner:
Source: FEED 2
Project: RNDLS DEVILS LAKE SIMULATION- C9803
Comments:

RICHARD SHOCKEY
ATTN: UND EERC
PO BOX 9018
GRAND FORKS ND 58202-9018

Approved by: _____

Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	2130	umhos/cm	
Dissolved Solids(C)-Total	1400	mg/L	Average
Hardness Total (as CaCO3)	493.	mg/L	Very High
Alkalinity (CaCO3)(Total)	328.	mg/L	Satisfactory
pH	7.97		
Iron (Fe)	< 0.007	mg/L	Satisfactory
Manganese (Mn)	< 0.002	mg/L	Satisfactory
Calcium (Ca)	69.0	mg/L	
Magnesium (Mg)	78.0	mg/L	
Sodium (Na)	259.	mg/L	Very High
Potassium (K)	40.5	mg/L	
Carbonate (CO3)	< 1	mg/L	
Bicarbonate (HCO3)	401.	mg/L	
Sulfate as (SO4)	626.	mg/L	Very High
Chloride	124.	mg/L	Average
Nitrate + Nitrite (N)	0.35	mg/L	Satisfactory
Silica (SiO2)	4.67	mg/L	
Fluoride (F) (IC)	0.140	mg/L	
Ammonia (N)	0.072	mg/L	
Hydroxide (OH)	< 1	mg/L	
Phosphorus (Total) (P)	0.149	mg/L	
Chemical Oxygen Demand	109.	mg/L	
Hardness (Total)	29.	gr/gal	
Suspended Solids (Total)	< 5	mg/L	
Turbidity	1.70	NTU	
Percent Sodium	50.7	%	
Sodium Adsorption Ratio	5.07		

Log Number: 98-C2745 cont'd

This water may prove harmful to individuals on sodium-restricted diets. Please consult your family doctor.

This water may exert a laxative effect upon persons unaccustomed to its high sulfate content.

This water is classified C3-S2 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is 0.47
This indicates a stable, non-corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Chemistry Division, Box 937, Bismarck, ND 58502-0937 (701) 328-6140.

APPENDIX G

FT DEMONSTRATION WATER SAMPLE ANALYTICAL RESULTS

North Dakota Department of Health
Chemistry Division

Original Report Date: 9/13/99 Report Date: 9/13/99

Log Number: 99-N489

Date Collected: 6/14/99 Date Received: 6/16/99
Time Collected: 10:00 Time Received: 10:47
Township: Range:
Section: Owner:
Source:
Project: BRAD STEVENS
Comments: DL-FTE CREEL BAY

EERC
PO BOX 9018

GRAND FORKS ND 58202

Approved by: _____ Organic

Approved by: _____ Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	1980	umhos/cm	
Dissolved Solids(C)-Total	1390	mg/L	Average
Hardness Total (as CaCO3)	498.	mg/L	Very High
Alkalinity (CaCO3)(Total)	341.	mg/L	Satisfactory
pH	8.45		
Iron (Fe)	0.056	mg/L	Satisfactory
Manganese (Mn)	0.011	mg/L	Satisfactory
Calcium (Ca)	72.5	mg/L	
Magnesium (Mg)	76.9	mg/L	
Sodium (Na)	262.	mg/L	Very High
Potassium (K)	41.2	mg/L	
Carbonate (CO3)	23.	mg/L	
Bicarbonate (HCO3)	369.	mg/L	
Sulfate as (SO4)	607.	mg/L	Very High
Chloride	122.	mg/L	Average
Nitrate + Nitrite (N)	0.12	mg/L	Satisfactory
Boron (B)	246.	ug/L	
Aluminum (Al)	82.	ug/L	
Silica (SiO2)	14.9	mg/L	
Beryllium (Be)	< 1	ug/L	
Chromium (Cr)	3.61	ug/L	
Nickel (Ni)	3.04	ug/L	
Copper (Cu)	2.68	ug/L	
Zinc (Zn)	7.38	ug/L	
Arsenic (As)	12.5	ug/L	
Selenium (Se)	9.89	ug/L	
Silver (Ag)	< 1	ug/L	
Cadmium (Cd)	< 1	ug/L	

Original Report Date: 9/13/99 Report Date: 9/13/99

Log Number: 99-N489 cont'd 99-N489

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Antimony (Sb)	< 1	ug/L	
Barium (Ba)	62.3	ug/L	
Thallium (Tl)	< 1	ug/L	
Lead (Pb)	< 1	ug/L	
Mercury (Hg)	< 0.2	ug/L	
Fluoride (F) (IC)	0.150	mg/L	
Ammonia (N)	0.085	mg/L	
Hydroxide (OH)	< 1	mg/L	
Chemical Oxygen Demand	33.	mg/L	
Hardness (Total)	29.	gr/gal	
Turbidity	5.10	NTU	
Percent Sodium	50.7	%	
Sodium Adsorption Ratio	5.11		
Hoelon	< 0.25	ug/L	
2,4-D	< 0.1	ug/L	
Dicamba	< 0.05	ug/L	
Dinoseb	< 0.1	ug/L	
MCPA	< 12	ug/L	
Tordon	< 0.05	ug/L	
Note:	Sample spike recovery 58%		
2,4,5-T	< 0.05	ug/L	
Silvex (2,4,5-TP)	< 0.05	ug/L	
Note:	Sample Spike Recovery 59%		
Pentachlorophenol	< 0.02	ug/L	
Acifluorfen	< 0.1	ug/L	
3,5 Dichlorobenzoic Acid	< 0.125	ug/L	
Aldicarb	< 0.5	ug/L	
Aldicarb-sulfoxide	< 0.5	ug/L	
Aldicarb-sulfone	< 0.5	ug/L	
Oxamyl	< 0.5	ug/L	
Carbofuran	< 0.5	ug/L	
3-Hydroxycarbofuran	< 0.5	ug/L	
Methomyl	< 0.5	ug/L	
Bromoxynil	< 0.025	ug/L	
Dichlorprop	< 0.15	ug/L	
Carbaryl	< 0.5	ug/L	
Bentazon	< 0.25	ug/L	
Benzene	< 0.5	ug/L	
Vinyl Chloride	< 0.5	ug/L	
Carbon Tetrachloride	< 0.5	ug/L	
Note:	Low spike recovery: 46%		
1,2-Dichloroethane	< 0.5	ug/L	
Trichloroethylene	< 0.5	ug/L	
1,1-Dichloroethylene	< 0.5	ug/L	

Original Report Date: 9/13/99 Report Date: 9/13/99

Log Number: 99-N489 cont'd 99-N489

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
1,1,1-Trichloroethane	< 0.5	ug/L	
p-Dichlorobenzene	< 0.5	ug/L	
Acetone	< 50	ug/L	
2-Butanone (MEK)	< 50	ug/L	
2-Hexanone	< 50	ug/L	
4-Methyl-2-pentanone	< 50	ug/L	
Chloroform	< 0.5	ug/L	
Bromodichloromethane	< 0.5	ug/L	
Chlorodibromomethane	< 0.5	ug/L	
Bromoform	< 0.5	ug/L	
trans1,2-Dichloroethylene	< 0.5	ug/L	
Chlorobenzene	< 0.5	ug/L	
m-Dichlorobenzene	< 0.5	ug/L	
Dichloromethane	< 0.5	ug/L	
cis-1,2-Dichloroethylene	< 0.5	ug/L	
o-Dichlorobenzene	< 0.5	ug/L	
Dibromomethane	< 0.5	ug/L	
1,1-Dichloropropene	< 0.5	ug/L	
Tetrachloroethylene	< 0.5	ug/L	
Toluene	< 0.5	ug/L	
Xylenes (Total)	< 0.5	ug/L	
1,1-Dichloroethane	< 0.5	ug/L	
1,2-Dichloropropane	< 0.5	ug/L	
1,1,2,2-Tetrachloroethane	< 0.5	ug/L	
Ethylbenzene	< 0.5	ug/L	
1,3-Dichlorpropane	< 0.5	ug/L	
Styrene	< 0.5	ug/L	
Note:	See Note at end of report		
Chloromethane	< 0.5	ug/L	
Bromomethane	< 0.5	ug/L	
1,2,3-Trichloropropane	< 0.5	ug/L	
1,1,1,2-Tetrachloroethane	< 0.5	ug/L	
Chloroethane	< 0.5	ug/L	
1,1,2-Trichloroethane	< 0.5	ug/L	
2,2-Dichloropropane	< 0.5	ug/L	
o-Chlorotoluene	< 0.5	ug/L	
p-Chlorotoluene	< 0.5	ug/L	
Bromobenzene	< 0.5	ug/L	
cis-1,3-Dichloropropene	< 0.5	ug/L	
1,2,4-Trimethylbenzene	< 0.5	ug/L	
1,2,4-Trichlorobenzene	< 0.5	ug/L	
1,2,3-Trichlorobenzene	< 0.5	ug/L	
n-Propylbenzene	< 0.5	ug/L	
n-Butylbenzene	< 0.5	ug/L	

Original Report Date: 9/13/99

Report Date: 9/13/99

Log Number: 99-N489 cont'd

99-N489

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Naphthalene	< 0.5	ug/L	
Hexachlorobutadiene	< 0.5	ug/L	
1,3,5-Trimethylbenzene	< 0.5	ug/L	
p-Isopropyltoluene	< 0.5	ug/L	
Isopropylbenzene	< 0.5	ug/L	
Tert-butylbenzene	< 0.5	ug/L	
Sec-butylbenzene	< 0.5	ug/L	
Fluorotrichloromethane	< 0.5	ug/L	
	Note: Low spike recovery: 64%		
Dichlorodifluoromethane	Not Reportable-QC Failure		
Bromochloromethane	< 0.5	ug/L	
trans-1,3-Dichloropropene	< 0.5	ug/L	
Ethylene dibromide (EDB)	< 0.5	ug/L	
1,2-Dibromo3chloropropane	< 0.5	ug/L	
	Note: Styrene was detected but not at high enough levels to quantitate. Remaining pesticides not reportable due to missed holding time.		

This water may prove harmful to individuals on sodium-restricted diets. Please consult your family doctor.

This water may exert a laxative effect upon persons unaccustomed to its high sulfate content.

This water is classified C3-S2 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is 0.99
This indicates a stable, non-corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Chemistry Division, Box 937, Bismarck, ND 58502-0937 (701) 328-6140.

PUBLIC HEALTH LABORATORY
NORTH DAKOTA DEPT. OF HEALTH

MICROBIOLOGY REPORT SUMMARY

PO BOX 5520
BISMARCK, ND 58506-5520

---------- Antimicrobial Susceptibility and Organism Identification Report ---------- ** FINAL **

Name : **STEVENS**
ID# : 3657

Room : FT
Service : TOT.COL.&SPC-SWM

Institution : .

Specimen Number : 00003657
Specimen Source : WATER SAMPLE
Ward of Isolation : TCS

Collected : 06/14/99 10:00
Received : 06/16/99 11:30

Miscellaneous Tests and Comments

BACTERIALLY UNSATISFAC-
TORY FOR DRINKING

STANDARD PLATE COUNT
SPC/ML=)6000
SPC UNSATISFACTORY

Comments :

Organisms Identified

Iso/Result	Identity	Tested	Comments
* 01	.	06/20/99	ENERGY & ENVIRO RESEARCH CENTER 15 N 23 ST GRAND FORKS ND 58203

---

* Susceptibilities, if performed, appear on the following page(s).

Tech : _____
Report Date : 08/02/99 15:52

Source : WATER SAMPLE
Collected : 06/14/99 10:00

Name : STEVENS
ID # : 3657

** FINAL **

North Dakota Department of Health
Chemistry Division

Original Report Date: 7/27/99 Report Date: 7/27/99

Log Number: 99-N437
Date Collected: 6/ 2/99 Date Received: 6/ 4/99
Time Collected: 12:30 Time Received: 11:23
Township: Range:
Section: Owner:
Source: TW-LINED LAGOON
Project:
Comments: 06021230 LINED TW POND
CHEMISTRY
PO BOX 937
2635 E MAIN
BISMARCK ND 58501

Approved by: _____ Organic

Approved by: _____ Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	377.	umhos/cm	
Dissolved Solids(C)-Total	227.	mg/L	Fairly Low
Hardness Total (as CaCO3)	107.	mg/L	Fairly Low
Alkalinity (CaCO3)(Total)	90.	mg/L	Low
pH	6.75		
Iron (Fe)	0.024	mg/L	Satisfactory
Manganese (Mn)	< 0.002	mg/L	Satisfactory
Calcium (Ca)	25.7	mg/L	
Magnesium (Mg)	10.5	mg/L	
Sodium (Na)	33.3	mg/L	Fairly Low
Potassium (K)	5.3	mg/L	
Carbonate (CO3)	< 1	mg/L	
Bicarbonate (HCO3)	110.	mg/L	
Sulfate as (SO4)	79.9	mg/L	Fairly Low
Chloride	15.8	mg/L	Low
Nitrate + Nitrite (N)	< 0.02	mg/L	Satisfactory
Boron (B)	< 50	ug/L	
Aluminum (Al)	< 50	ug/L	
Silica (SiO2)	3.83	mg/L	
Beryllium (Be)	< 1	ug/L	
Chromium (Cr)	< 1	ug/L	
Nickel (Ni)	1.15	ug/L	
Copper (Cu)	1.68	ug/L	
Zinc (Zn)	3.70	ug/L	
Arsenic (As)	1.15	ug/L	
Selenium (Se)	< 1	ug/L	
Silver (Ag)	< 1	ug/L	
Cadmium (Cd)	< 1	ug/L	
Antimony (Sb)	< 1	ug/L	
Barium (Ba)	35.0	ug/L	

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N437 cont'd

99-N437

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Thallium (Tl)	< 1	ug/L	
Lead (Pb)	< 1	ug/L	
Mercury (Hg)	< 0.2	ug/L	
Fluoride (F) (IC)	0.050	mg/L	
Ammonia (N)	0.049	mg/L	
Hydroxide (OH)	< 1	mg/L	
Chemical Oxygen Demand	8.	mg/L	
Hardness (Total)	6.	gr/gal	
Turbidity	1.10	NTU	
Percent Sodium	38.7	%	
Sodium Adsorption Ratio	1.40		
Aldrin	< 0.05	ug/L	
BHC (Alpha)	< 0.025	ug/L	
BHC (Beta)	< 0.025	ug/L	
BHC (Delta)	< 0.02	ug/L	
Lindane	< 0.025	ug/L	
DDD	< 0.025	ug/L	
DDE	< 0.025	ug/L	
DDT	< 0.025	ug/L	
Dieldrin	< 0.025	ug/L	
Endosulfan I	< 0.025	ug/L	
Endosulfan II	< 0.025	ug/L	
Endosulfan Sulfate	< 0.025	ug/L	
Endrin	< 0.025	ug/L	
Endrin Aldehyde	< 0.02	ug/L	
Heptachlor	< 0.05	ug/L	
Heptachlor Epoxide	< 0.025	ug/L	
Methoxychlor	< 0.1	ug/L	
Hoelon	< 0.25	ug/L	
Toxaphene	< 1	ug/L	
Chlordane (gamma)	< 0.05	ug/L	
Chlordane (alpha)	< 0.05	ug/L	
trans-Nonachlor	< 0.025	ug/L	
Endrin Ketone	< 0.025	ug/L	
Alachlor	< 0.2	ug/L	
Chlorpyrifos	< 1	ug/L	
Diazinon	< 0.1	ug/L	
Malathion	< 0.1	ug/L	
Parathion Ethyl	< 0.5	ug/L	
Parathion Methyl	< 0.5	ug/L	
Fenvalerate	< 0.5	ug/L	
Cyanazine	< 0.2	ug/L	
Far-Go (Triallate)	< 0.025	ug/L	
Treflan (Trifluralin)	< 0.025	ug/L	

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N437 cont'd

99-N437

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Simazine	< 0.5	ug/L	
Ethalfluralin	< 0.025	ug/L	
Atrazine	< 0.25	ug/L	
Prowl	< 0.025	ug/L	
Metribuzine	< 0.05	ug/L	
Metolachlor	< 0.2	ug/L	
2,4-D	< 0.1	ug/L	
Dicamba	< 0.05	ug/L	
Note:	Blank Spike recovery 57%.		
Dinoseb	< 0.1	ug/L	
Note:	Blank Spike recovery 54%.		
MCPA	< 12	ug/L	
Tordon	< 0.05	ug/L	
2,4,5-T	< 0.05	ug/L	
Silvex (2,4,5-TP)	< 0.05	ug/L	
Pentachlorophenol	< 0.02	ug/L	
Note:	Blank Spike recovery 58%.		
Acifluorfen	< 0.1	ug/L	
3,5 Dichlorobenzoic Acid	< 0.125	ug/L	
Note:	Blank Spike recovery 56%.		
Aldicarb	< 0.5	ug/L	
Aldicarb-sulfoxide	< 0.5	ug/L	
Aldicarb-sulfone	< 0.5	ug/L	
Oxamyl	< 0.5	ug/L	
Carbofuran	< 0.5	ug/L	
3-Hydroxycarbofuran	< 0.5	ug/L	
Methomyl	< 0.5	ug/L	
Bromoxynil	< 0.025	ug/L	
Note:	Blank Spike recovery 54%.		
Dichlorprop	< 0.15	ug/L	
Carbaryl	< 0.5	ug/L	
Bentazon	< 0.25	ug/L	
Benzene	< 0.5	ug/L	
Vinyl Chloride	< 0.5	ug/L	
Carbon Tetrachloride	< 0.5	ug/L	
1,2-Dichloroethane	< 0.5	ug/L	
Trichloroethylene	< 0.5	ug/L	
1,1-Dichloroethylene	< 0.5	ug/L	
1,1,1-Trichloroethane	< 0.5	ug/L	
p-Dichlorobenzene	< 0.5	ug/L	
Acetone	< 50	ug/L	
2-Butanone (MEK)	< 50	ug/L	
2-Hexanone	< 50	ug/L	
4-Methyl-2-pentanone	< 50	ug/L	

Log Number: 99-N437 cont'd

99-N437

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Chloroform	< 0.5	ug/L	
Bromodichloromethane	< 0.5	ug/L	
Chlorodibromomethane	< 0.5	ug/L	
Bromoform	< 0.5	ug/L	
trans1,2-Dichloroethylene	< 0.5	ug/L	
Chlorobenzene	< 0.5	ug/L	
m-Dichlorobenzene	< 0.5	ug/L	
Dichloromethane	Not Reportable-QC Failure		
cis-1,2-Dichloroethylene	< 0.5	ug/L	
o-Dichlorobenzene	< 0.5	ug/L	
Dibromomethane	< 0.5	ug/L	
1,1-Dichloropropene	< 0.5	ug/L	
Tetrachloroethylene	< 0.5	ug/L	
Toluene	< 0.5	ug/L	
Xylenes (Total)	< 0.5	ug/L	
1,1-Dichloroethane	< 0.5	ug/L	
1,2-Dichloropropane	< 0.5	ug/L	
1,1,2,2-Tetrachloroethane	< 0.5	ug/L	
Ethylbenzene	< 0.5	ug/L	
1,3-Dichlorpropane	< 0.5	ug/L	
Styrene	< 0.5	ug/L	
Note:	See comments below		
Chloromethane	< 0.5	ug/L	
Bromomethane	< 0.5	ug/L	
1,2,3-Trichloropropane	< 0.5	ug/L	
1,1,1,2-Tetrachloroethane	< 0.5	ug/L	
Chloroethane	< 0.5	ug/L	
1,1,2-Trichloroethane	< 0.5	ug/L	
2,2-Dichloropropane	< 0.5	ug/L	
o-Chlorotoluene	< 0.5	ug/L	
p-Chlorotoluene	< 0.5	ug/L	
Bromobenzene	< 0.5	ug/L	
cis-1,3-Dichloropropene	< 0.5	ug/L	
1,2,4-Trimethylbenzene	< 0.5	ug/L	
1,2,4-Trichlorobenzene	< 0.5	ug/L	
1,2,3-Trichlorobenzene	< 0.5	ug/L	
n-Propylbenzene	< 0.5	ug/L	
n-Butylbenzene	< 0.5	ug/L	
Naphthalene	< 0.5	ug/L	
Hexachlorobutadiene	< 0.5	ug/L	
1,3,5-Trimethylbenzene	< 0.5	ug/L	
p-Isopropyltoluene	< 0.5	ug/L	
Isopropylbenzene	< 0.5	ug/L	
Tert-butylbenzene	< 0.5	ug/L	

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N437 cont'd

99-N437

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Sec-butylbenzene	< 0.5	ug/L	
Fluorotrichloromethane	< 0.5	ug/L	
Dichlorodifluoromethane	Not Reportable-QC Failure		
Bromochloromethane	< 0.5	ug/L	
trans-1,3-Dichloropropene	< 0.5	ug/L	
Ethylene dibromide (EDB)	< 0.5	ug/L	
1,2-Dibromo3chloropropane	< 0.5	ug/L	
	Styrene was detected but not at high enough levels to be quantitated. Herbicide Surrogate recovery 12%.		

This water is classified C2-S1 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is -1.67
This may indicate a potentially corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Division of Municipal Facilities, Box 5520, Bismarck, ND 58502-5520.
Drinking Water Program, (701) 328-5211.

PUBLIC HEALTH LABORATORY
NORTH DAKOTA DEPT. OF HEALTH

MICROBIOLOGY REPORT SUMMARY

PO BOX 5520
BISMARCK, ND 58506-5520

Antimicrobial Susceptibility and Organism Identification Report

** FINAL **

Name : STEVENS,DL FTE
ID# : 3271
Room : F8
Service : TOT.COL.&SPC-SWM
Institution : .

Specimen Number : 00003271
Specimen Source : WATER SAMPLE
Ward of Isolation : TCS

Collected : 06/02/99 12:30
Received : 06/04/99 10:40

Miscellaneous Tests and Comments

BACTERIALLY UNSATISFAC-
TORY FOR DRINKING

STANDARD PLATE COUNT
SPC/ML=)6000
SPC UNSATISFACTORY

Comments : TW LINED

Organisms Identified

Iso/Result	Identity	Tested	Comments
* 01	.	06/07/99	BRAD STEVENS 15 N 23 ST GRAND FORKS ND 58203

* Susceptibilities, if performed, appear on the following page(s).

Tech : _____
Report Date : 08/02/99 15:54

Source : WATER SAMPLE
Collected : 06/02/99 12:30

Name : STEVENS,DL FTE
ID # : 3271

** FINAL **

North Dakota Department of Health
Chemistry Division

Original Report Date: 7/27/99 Report Date: 7/27/99

Log Number: 99-N438
Date Collected: 6/ 2/99 Date Received: 6/ 4/99
Time Collected: 12:20 Time Received: 11:23
Township: Range:
Section: Owner:
Source: UNLINED TW POND
Project:
Comments: 06021220 UNLINED TW POND
CHEMISTRY
PO BOX 937
2635 E MAIN
BISMARCK ND 58501

Approved by: _____ Organic

Approved by: _____ Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	498.	umhos/cm	
Dissolved Solids(C)-Total	315.	mg/L	Fairly Low
Hardness Total (as CaCO3)	188.	mg/L	Satisfactory
Alkalinity (CaCO3)(Total)	82.	mg/L	Low
pH	6.47		
Iron (Fe)	0.646	mg/L	High
Manganese (Mn)	0.015	mg/L	Satisfactory
Calcium (Ca)	50.6	mg/L	
Magnesium (Mg)	14.9	mg/L	
Sodium (Na)	29.1	mg/L	Fairly Low
Potassium (K)	3.4	mg/L	
Carbonate (CO3)	< 1	mg/L	
Bicarbonate (HCO3)	100.	mg/L	
Sulfate as (SO4)	156.	mg/L	Satisfactory
Chloride	9.38	mg/L	Low
Nitrate + Nitrite (N)	0.10	mg/L	Satisfactory
Boron (B)	< 50	ug/L	
Aluminum (Al)	191.	ug/L	
Silica (SiO2)	11.1	mg/L	
Beryllium (Be)	< 1	ug/L	
Chromium (Cr)	< 1	ug/L	
Nickel (Ni)	2.26	ug/L	
Copper (Cu)	< 1	ug/L	
Zinc (Zn)	6.21	ug/L	
Arsenic (As)	< 1	ug/L	
Selenium (Se)	< 1	ug/L	
Silver (Ag)	< 1	ug/L	
Cadmium (Cd)	< 1	ug/L	
Antimony (Sb)	< 1	ug/L	
Barium (Ba)	43.0	ug/L	

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N438 cont'd

99-N438

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Thallium (Tl)	< 1	ug/L	
Lead (Pb)	< 1	ug/L	
Mercury (Hg)	< 0.2	ug/L	
Fluoride (F) (IC)	0.130	mg/L	
Ammonia (N)	0.037	mg/L	
Hydroxide (OH)	< 1	mg/L	
Chemical Oxygen Demand	< 5	mg/L	
Hardness (Total)	11.	gr/gal	
Turbidity	10.1	NTU	
Percent Sodium	24.7	%	
Sodium Adsorption Ratio	0.92		
Aldrin	< 0.05	ug/L	
BHC (Alpha)	< 0.025	ug/L	
BHC (Beta)	< 0.025	ug/L	
BHC (Delta)	< 0.02	ug/L	
Lindane	< 0.025	ug/L	
DDD	< 0.025	ug/L	
DDE	< 0.025	ug/L	
DDT	< 0.025	ug/L	
Dieldrin	< 0.025	ug/L	
Endosulfan I	< 0.025	ug/L	
Endosulfan II	< 0.025	ug/L	
Endosulfan Sulfate	< 0.025	ug/L	
Endrin	< 0.025	ug/L	
Endrin Aldehyde	< 0.02	ug/L	
Heptachlor	< 0.05	ug/L	
Heptachlor Epoxide	< 0.025	ug/L	
Methoxychlor	< 0.1	ug/L	
Hoelon	< 0.25	ug/L	
Toxaphene	< 1	ug/L	
Chlordane (gamma)	< 0.05	ug/L	
Chlordane (alpha)	< 0.05	ug/L	
trans-Nonachlor	< 0.025	ug/L	
Endrin Ketone	< 0.025	ug/L	
Alachlor	< 0.2	ug/L	
Chlorpyrifos	< 1	ug/L	
Diazinon	< 0.1	ug/L	
Malathion	< 0.1	ug/L	
Parathion Ethyl	< 0.5	ug/L	
Parathion Methyl	< 0.5	ug/L	
Fenvalerate	< 0.5	ug/L	
Cyanazine	< 0.2	ug/L	
Far-Go (Triallate)	< 0.025	ug/L	
Treflan (Trifluralin)	< 0.025	ug/L	

Log Number: 99-N438 cont'd

99-N438

Analyte	Result	Units	Evaluation
	Chemical Analysis of Sample		
Simazine	< 0.5	ug/L	
Ethalfluralin	< 0.025	ug/L	
Atrazine	< 0.25	ug/L	
Prowl	< 0.025	ug/L	
Metribuzine	< 0.05	ug/L	
Metolachlor	< 0.2	ug/L	
2,4-D	< 0.1	ug/L	
Dicamba	< 0.05	ug/L	
	Note: Blank Spike recovery 57%.		
Dinoseb	< 0.1	ug/L	
	Note: Blank Spike recovery 54%.		
MCPA	< 12	ug/L	
Tordon	< 0.05	ug/L	
2,4,5-T	< 0.05	ug/L	
Silvex (2,4,5-TP)	< 0.05	ug/L	
Pentachlorophenol	< 0.02	ug/L	
	Note: Blank Spike recovery 58%.		
Acifluorfen	< 0.1	ug/L	
3,5 Dichlorobenzoic Acid	< 0.125	ug/L	
	Note: Blank Spike recovery 56%.		
Aldicarb	< 0.5	ug/L	
Aldicarb-sulfoxide	< 0.5	ug/L	
Aldicarb-sulfone	< 0.5	ug/L	
Oxamyl	< 0.5	ug/L	
Carbofuran	< 0.5	ug/L	
3-Hydroxycarbofuran	< 0.5	ug/L	
Methomyl	< 0.5	ug/L	
Bromoxynil	< 0.025	ug/L	
	Note: Blank Spike recovery 54%.		
Dichlorprop	< 0.15	ug/L	
Carbaryl	< 0.5	ug/L	
Bentazon	< 0.25	ug/L	
Benzene	< 0.5	ug/L	
Vinyl Chloride	< 0.5	ug/L	
Carbon Tetrachloride	< 0.5	ug/L	
1,2-Dichloroethane	< 0.5	ug/L	
Trichloroethylene	< 0.5	ug/L	
1,1-Dichloroethylene	< 0.5	ug/L	
1,1,1-Trichloroethane	< 0.5	ug/L	
p-Dichlorobenzene	< 0.5	ug/L	
Acetone	< 50	ug/L	
2-Butanone (MEK)	< 50	ug/L	
2-Hexanone	< 50	ug/L	
4-Methyl-2-pentanone	< 50	ug/L	

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N438 cont'd

99-N438

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Chloroform	< 0.5	ug/L	
Bromodichloromethane	< 0.5	ug/L	
Chlorodibromomethane	< 0.5	ug/L	
Bromoform	< 0.5	ug/L	
trans1,2-Dichloroethylene	< 0.5	ug/L	
Chlorobenzene	< 0.5	ug/L	
m-Dichlorobenzene	< 0.5	ug/L	
Dichloromethane	Not Reportable-QC Failure		
cis-1,2-Dichloroethylene	< 0.5	ug/L	
o-Dichlorobenzene	< 0.5	ug/L	
Dibromomethane	< 0.5	ug/L	
1,1-Dichloropropene	< 0.5	ug/L	
Tetrachloroethylene	< 0.5	ug/L	
Toluene	< 0.5	ug/L	
Xylenes (Total)	< 0.5	ug/L	
1,1-Dichloroethane	< 0.5	ug/L	
1,2-Dichloropropane	< 0.5	ug/L	
1,1,2,2-Tetrachloroethane	< 0.5	ug/L	
Ethylbenzene	< 0.5	ug/L	
1,3-Dichlorpropane	< 0.5	ug/L	
Styrene	< 0.5	ug/L	
Note:	See comments below		
Chloromethane	< 0.5	ug/L	
Bromomethane	< 0.5	ug/L	
1,2,3-Trichloropropane	< 0.5	ug/L	
1,1,1,2-Tetrachloroethane	< 0.5	ug/L	
Chloroethane	< 0.5	ug/L	
1,1,2-Trichloroethane	< 0.5	ug/L	
2,2-Dichloropropane	< 0.5	ug/L	
o-Chlorotoluene	< 0.5	ug/L	
p-Chlorotoluene	< 0.5	ug/L	
Bromobenzene	< 0.5	ug/L	
cis-1,3-Dichloropropene	< 0.5	ug/L	
1,2,4-Trimethylbenzene	< 0.5	ug/L	
1,2,4-Trichlorobenzene	< 0.5	ug/L	
1,2,3-Trichlorobenzene	< 0.5	ug/L	
n-Propylbenzene	< 0.5	ug/L	
n-Butylbenzene	< 0.5	ug/L	
Naphthalene	< 0.5	ug/L	
Hexachlorobutadiene	< 0.5	ug/L	
1,3,5-Trimethylbenzene	< 0.5	ug/L	
p-Isopropyltoluene	< 0.5	ug/L	
Isopropylbenzene	< 0.5	ug/L	
Tert-butylbenzene	< 0.5	ug/L	

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N438 cont'd

99-N438

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Sec-butylbenzene	< 0.5	ug/L	
Fluorotrichloromethane	< 0.5	ug/L	
Dichlorodifluoromethane	Not Reportable-QC Failure		
Bromochloromethane	< 0.5	ug/L	
trans-1,3-Dichloropropene	< 0.5	ug/L	
Ethylene dibromide (EDB)	< 0.5	ug/L	
1,2-Dibromo3chloropropane	< 0.5	ug/L	
	Styrene was detected but not at high enough levels to be quantitated. Herbicide Surrogate recovery 13%.		

This water could cause staining of laundry and plumbing fixtures due to its high iron content.

This water is classified C2-S1 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is -1.69
This may indicate a potentially corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Division of Municipal Facilities, Box 5520, Bismarck, ND 58502-5520.
Drinking Water Program, (701) 328-5211.

PUBLIC HEALTH LABORATORY
NORTH DAKOTA DEPT. OF HEALTH

MICROBIOLOGY REPORT SUMMARY

PO BOX 5520
BISMARCK, ND 58506-5520

Antimicrobial Susceptibility and Organism Identification Report

** FINAL **

Name : STEVENS,PL FTE
ID# : 3270

Room : F8
Service : TOT.COL.&SPC-SWM

Institution : .

Specimen Number : 00003270
Specimen Source : WATER SAMPLE
Ward of Isolation : TCS

Collected : 06/02/99 12:20
Received : 06/04/99 10:40

Miscellaneous Tests and Comments

BACTERIALLY UNSATISFAC-
TORY FOR DRINKING

STANDARD PLATE COUNT
SPC/ML=)6000
SPC UNSATISFACTORY

Comments : TW UNLINED

Organisms Identified

Iso/Result	Identity	Tested	Comments
* 01	.	06/07/99	BRAD STEVENS 15 N 23 ST GRAND FORKS ND 58203

---

* Susceptibilities, if performed, appear on the following page(s).

Tech :
Report Date : 08/02/99 15:54

Source : WATER SAMPLE
Collected : 06/02/99 12:20

Name : STEVENS,PL FTE
ID # : 3270

** FINAL **

North Dakota Department of Health
Chemistry Division

Original Report Date: 7/27/99 Report Date: 7/27/99

Log Number: 99-N439
Date Collected: 6/ 2/99 Date Received: 6/ 4/99
Time Collected: 13:15 Time Received: 11:23
Township: Range:
Section: Owner:
Source: BRINE
Project:
Comments: 06021315 BRINE
CHEMISTRY
PO BOX 937
2635 E MAIN
BISMARCK ND 58501

Approved by: Mike Born
Organic

Approved by: Mike Born
Inorganic

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Conductivity	12800	umhos/cm	
Dissolved Solids(C)-Total	11500	mg/L	Very High
Hardness Total (as CaCO3)	3150	mg/L	Very High
Alkalinity (CaCO3)(Total)	1620	mg/L	Very High
pH	9.10		
Iron (Fe)	< 0.007	mg/L	Satisfactory
Manganese (Mn)	< 0.002	mg/L	Satisfactory
Calcium (Ca)	92.3	mg/L	
Magnesium (Mg)	710.	mg/L	
Sodium (Na)	2430	mg/L	Very High
Potassium (K)	378.	mg/L	
Carbonate (CO3)	407.	mg/L	
Bicarbonate (HCO3)	1150	mg/L	
Sulfate as (SO4)	5740	mg/L	Very High
Chloride	1140	mg/L	Very High
Fluoride (F)	1.04	mg/L	
Nitrate + Nitrite (N)	< 0.02	mg/L	Satisfactory
Boron (B)	257.	ug/L	
Aluminum (Al)	< 50	ug/L	
Silica (SiO2)	17.8	mg/L	
Beryllium (Be)	< 5	ug/L	
Chromium (Cr)	21.6	ug/L	
Nickel (Ni)	18.0	ug/L	
Copper (Cu)	43.6	ug/L	
Zinc (Zn)	< 5	ug/L	
Arsenic (As)	117.	ug/L	
Selenium (Se)	36.0	ug/L	
Silver (Ag)	< 5	ug/L	
Cadmium (Cd)	< 5	ug/L	
Antimony (Sb)	< 5	ug/L	

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N439 cont'd

99-N439

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Barium (Ba)	157.	ug/L	
Thallium (Tl)	< 5	ug/L	
Lead (Pb)	< 5	ug/L	
Mercury (Hg)	< 0.2	ug/L	
Ammonia (N)	< 0.01	mg/L	
Hydroxide (OH)	< 1	mg/L	
Chemical Oxygen Demand	256.	mg/L	
Hardness (Total)	184.	gr/gal	
Percent Sodium	59.1	%	
Sodium Adsorption Ratio	18.8		
Aldrin	< 0.05	ug/L	
Note:	Matrix Suspect		
BHC (Alpha)	< 0.025	ug/L	
Note:	Matrix Suspect		
BHC (Beta)	< 0.025	ug/L	
Note:	Matrix Suspect		
BHC (Delta)	< 0.02	ug/L	
Note:	Matrix Suspect		
Lindane	< 0.025	ug/L	
Note:	Matrix Suspect		
DDD	< 0.025	ug/L	
Note:	Matrix Suspect		
DDE	< 0.025	ug/L	
Note:	Matrix Suspect		
DDT	< 0.025	ug/L	
Note:	Matrix Suspect		
Dieldrin	< 0.025	ug/L	
Note:	Matrix Suspect		
Endosulfan I	< 0.025	ug/L	
Note:	Matrix Suspect		
Endosulfan II	< 0.025	ug/L	
Note:	Matrix Suspect		
Endosulfan Sulfate	< 0.025	ug/L	
Note:	Matrix Suspect		
Endrin	< 0.025	ug/L	
Note:	Matrix Suspect		
Endrin Aldehyde	< 0.02	ug/L	
Note:	Matrix Suspect		
Heptachlor	< 0.05	ug/L	
Note:	Matrix Suspect		
Heptachlor Epoxide	< 0.025	ug/L	
Note:	Matrix Suspect		
Methoxychlor	< 0.1	ug/L	
Note:	Matrix Suspect		

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N439 cont'd

99-N439

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Hoelon	< 0.25	ug/L	
Toxaphene	< 1	ug/L	
	Note: Matrix Suspect		
Chlordane (gamma)	< 0.05	ug/L	
	Note: Matrix Suspect		
Chlordane (alpha)	< 0.05	ug/L	
	Note: Matrix Suspect		
trans-Nonachlor	< 0.025	ug/L	
	Note: Matrix Suspect		
Endrin Ketone	< 0.025	ug/L	
	Note: Matrix Suspect		
Alachlor	< 0.2	ug/L	
	Note: Matrix Suspect		
Chlorpyrifos	< 1	ug/L	
	Note: Matrix Suspect		
Diazinon	< 0.1	ug/L	
	Note: Matrix Suspect		
Malathion	< 0.1	ug/L	
	Note: Matrix Suspect		
Parathion Ethyl	< 0.5	ug/L	
	Note: Matrix Suspect		
Parathion Methyl	< 0.5	ug/L	
	Note: Matrix Suspect		
Fenvalerate	< 0.5	ug/L	
	Note: Matrix Suspect		
Cyanazine	< 0.2	ug/L	
	Note: Matrix Suspect		
Far-Go (Triallate)	< 0.025	ug/L	
	Note: Matrix Suspect		
Treflan (Trifluralin)	< 0.025	ug/L	
	Note: Matrix Suspect		
Simazine	< 0.5	ug/L	
	Note: Matrix Suspect		
Ethalfluralin	< 0.025	ug/L	
	Note: Matrix Suspect		
Atrazine	< 0.25	ug/L	
	Note: Matrix Suspect		
Prowl	< 0.025	ug/L	
	Note: Matrix Suspect		
Metribuzine	< 0.05	ug/L	
	Note: Matrix Suspect		
Metolachlor	< 0.2	ug/L	
	Note: Matrix Suspect		
2,4-D	< 0.1	ug/L	

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N439 cont'd

99-N439

Analyte	Result	Units	Evaluation
	Chemical Analysis of Sample		
Dicamba	< 0.05	ug/L	
Note:	Blank Spike recovery 57%.		
Dinoseb	< 0.1	ug/L	
Note:	Blank Spike recovery 54%		
MCPA	< 12	ug/L	
Tordon	< 0.05	ug/L	
2,4,5-T	< 0.05	ug/L	
Silvex (2,4,5-TP)	< 0.05	ug/L	
Pentachlorophenol	< 0.02	ug/L	
Note:	Blank Spike recovery 58%.		
Acifluorfen	< 0.1	ug/L	
3,5 Dichlorobenzoic Acid	< 0.125	ug/L	
Note:	Blank Spike recovery 56%.		
Aldicarb	< 0.5	ug/L	
Aldicarb-sulfoxide	< 0.5	ug/L	
Aldicarb-sulfone	< 0.5	ug/L	
Oxamyl	< 0.5	ug/L	
Carbofuran	< 0.5	ug/L	
3-Hydroxycarbofuran	< 0.5	ug/L	
Methomyl	< 0.5	ug/L	
Bromoxynil	< 0.025	ug/L	
Note:	Blank Spike recovery 54%.		
Dichlorprop	< 0.15	ug/L	
Carbaryl	< 0.5	ug/L	
Bentazon	< 0.25	ug/L	
Benzene	< 0.5	ug/L	
Vinyl Chloride	< 0.5	ug/L	
Carbon Tetrachloride	< 0.5	ug/L	
1,2-Dichloroethane	< 0.5	ug/L	
Trichloroethylene	< 0.5	ug/L	
1,1-Dichloroethylene	< 0.5	ug/L	
1,1,1-Trichloroethane	< 0.5	ug/L	
p-Dichlorobenzene	< 0.5	ug/L	
Acetone	< 50	ug/L	
2-Butanone (MEK)	< 50	ug/L	
2-Hexanone	< 50	ug/L	
4-Methyl-2-pentanone	< 50	ug/L	
Chloroform	< 0.5	ug/L	
Bromodichloromethane	< 0.5	ug/L	
Chlorodibromomethane	< 0.5	ug/L	
Bromoform	< 0.5	ug/L	
trans1,2-Dichloroethylene	< 0.5	ug/L	
Chlorobenzene	< 0.5	ug/L	
m-Dichlorobenzene	< 0.5	ug/L	

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N439 cont'd

99-N439

Chemical Analysis of Sample

Analyte	Result	Units	Evaluation
Dichloromethane	Not Reportable-QC Failure		
cis-1,2-Dichloroethylene	< 0.5	ug/L	
o-Dichlorobenzene	< 0.5	ug/L	
Dibromomethane	< 0.5	ug/L	
1,1-Dichloropropene	< 0.5	ug/L	
Tetrachloroethylene	< 0.5	ug/L	
Toluene	< 0.5	ug/L	
Xylenes (Total)	< 0.5	ug/L	
1,1-Dichloroethane	< 0.5	ug/L	
1,2-Dichloropropane	< 0.5	ug/L	
1,1,2,2-Tetrachloroethane	< 0.5	ug/L	
Ethylbenzene	< 0.5	ug/L	
1,3-Dichlorpropane	< 0.5	ug/L	
Styrene	< 0.5	ug/L	
Chloromethane	< 0.5	ug/L	
Bromomethane	< 0.5	ug/L	
1,2,3-Trichloropropane	< 0.5	ug/L	
1,1,1,2-Tetrachloroethane	< 0.5	ug/L	
Chloroethane	< 0.5	ug/L	
1,1,2-Trichloroethane	< 0.5	ug/L	
2,2-Dichloropropane	< 0.5	ug/L	
o-Chlorotoluene	< 0.5	ug/L	
p-Chlorotoluene	< 0.5	ug/L	
Bromobenzene	< 0.5	ug/L	
cis-1,3-Dichloropropene	< 0.5	ug/L	
1,2,4-Trimethylbenzene	< 0.5	ug/L	
1,2,4-Trichlorobenzene	< 0.5	ug/L	
1,2,3-Trichlorobenzene	< 0.5	ug/L	
n-Propylbenzene	< 0.5	ug/L	
n-Butylbenzene	< 0.5	ug/L	
Naphthalene	< 0.5	ug/L	
Hexachlorobutadiene	< 0.5	ug/L	
1,3,5-Trimethylbenzene	< 0.5	ug/L	
p-Isopropyltoluene	< 0.5	ug/L	
Isopropylbenzene	< 0.5	ug/L	
Tert-butylbenzene	< 0.5	ug/L	
Sec-butylbenzene	< 0.5	ug/L	
Fluorotrichloromethane	< 0.5	ug/L	
Dichlorodifluoromethane	Not Reportable-QC Failure		
Bromochloromethane	< 0.5	ug/L	
trans-1,3-Dichloropropene	< 0.5	ug/L	
Ethylene dibromide (EDB)	< 0.5	ug/L	
1,2-Dibromo3chloropropane	< 0.5	ug/L	

"Matrix Suspect" analytes

Original Report Date: 7/27/99

Report Date: 7/27/99

Log Number: 99-N439 cont'd

99-N439

Analyte	Result	Units	Evaluation
			should be considered suspect due to low Surr. Recovery (55%) and matrix interferences from sample Herbicide Surrogate recovery 0%.

This water may prove harmful to individuals on sodium-restricted diets. Please consult your family doctor.

This water may exert a laxative effect upon persons unaccustomed to its high sulfate content.

This water is classified C4-S4 for irrigation.
Contact your county agent for more information.

The Langelier saturation index at 10 C is 2.42
This indicates a stable, non-corrosive water.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For further information contact:
North Dakota Department of Health
Division of Municipal Facilities, Box 5520, Bismarck, ND 58502-5520.
Drinking Water Program, (701) 328-5211.

PUBLIC HEALTH LABORATORY
NORTH DAKOTA DEPT. OF HEALTH

MICROBIOLOGY REPORT SUMMARY

PO BOX 5520
BISMARCK, ND 58506-5520

Antimicrobial Susceptibility and Organism Identification Report

** FINAL **

Name : STEVENS,DL FTE
ID# : 3272

Room : FC
Service : TOT.COL.&SPC-SWM

Institution : .

Specimen Number : 00003272
Specimen Source : WATER SAMPLE
Ward of Isolation : TCS

Collected : 06/02/99 13:15
Received : 06/04/99 10:40

Miscellaneous Tests and Comments

BACTERIALLY SATISFACTORY
FOR DRINKING

STANDARD PLATE COUNT
SPC/ML=)6000
SPC UNSATISFACTORY

Comments : BRINE

Organisms Identified

Iso/Result	Identity	Tested	Comments
* 01	.	06/06/99	BRAD STEVENS 15 N 23 ST GRAND FORKS ND 58203

---

* Susceptibilities, if performed, appear on the following page(s).

Tech : _____
Report Date : 08/02/99 15:54

Source : WATER SAMPLE
Collected : 06/02/99 13:15

Name : STEVENS,DL FTE
ID # : 3272

** FINAL **

APPENDIX H

NDPDES DISCHARGE-MONITORING REPORTS AND ANALYTICAL RESULTS

NORTH DAKOTA DEPARTMENT OF HEALTH
Discharge Monitoring Report Form

Facility: UND Energy & Environmental Research Center. Dewatering Permit Number: NDG070072
Location Description: 001A Monitoring Period From: January 1,1999 to: March 31,1999

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQ OF ANALYSIS	SAMPLE TYPE
		AVERAGE	MAXIMUM	UNITS	MINIMUM	AVERAGE	MAXIMUM	UNITS			
pH	SAMPLE VALUE					8.69					
	PERMIT LIMIT				6.0		9.0	S.U.		1/7	GRAB
TOTAL SUSPENDED SOLIDS (TSS)	SAMPLE VALUE					NA					
	PERMIT LIMIT				Report	Report	30	mg/l		1/7	GRAB
5-DAY 20°C BOD	SAMPLE VALUE					NA					
	PERMIT LIMIT				Report	Report	25	mg/l		1/7	GRAB
CONDUCTIVITY (EFFLUENT)	SAMPLE VALUE					2,290					
	PERMIT LIMIT						Report	umhos/cm		A/	GRAB
CONDUCTIVITY (SOURCE WATER)	SAMPLE VALUE					2,100					
	PERMIT LIMIT						Report	umhos/cm		A/	GRAB
TEMPERATURE (EFFLUENT)	SAMPLE VALUE										
	PERMIT LIMIT						Report	(°F)		A/	GRAB
FLOW	SAMPLE VALUE		201,600	GPD							
	PERMIT LIMIT		REPORT	GAL/DAY						DAILY	INST
TOTAL FLOW (DRAIN)	SAMPLE VALUE		0.105	MGAL							
	PERMIT LIMIT		REPORT	MGAL						1/PERIOD	CALC

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein; and based on my inquiry of those individuals responsible for obtaining the information , I believe the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment.

BRADLEY G. STEVENS, P.E.	Bradley G. Stevens	701-777-5293	04/21/99
Typed or Printed Name/Title Principal Executive Officer	Signature of Principle Executive Officer or Authorized Agent	Telephone	Year/Month/Day

A/. A SAMPLE OF THE EFFLUENT AND SOURCE WATER SHALL BE COLLECTED AND ANALYZED FOR TEMPERATURE, GENERAL CHEMISTRY AND CONDUCTIVITY PRIOR TO DISCHARGE.
B/. IN ADDITION, THE DATES AND TIMES OF DISCHARGE SHALL BE REPORTED.

NORTH DAKOTA DEPARTMENT OF HEALTH
Discharge Monitoring Report Form

Facility: UND Energy & Environmental Research Center. Dewatering Permit Number: NDG070072
Location Description: 001A Monitoring Period From: April 1,1999 to: June 30,1999

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQ OF ANALYSIS	SAMPLE TYPE
		AVERAGE	MAXIMUM	UNITS	MINIMUM	AVERAGE	MAXIMUM	UNITS			
pH	SAMPLE VALUE				7.82	8.39	8.78	SU			
	PERMIT LIMIT				6.0		9.0	S.U.		1/7	GRAB
TOTAL SUSPENDED SOLIDS (TSS)	SAMPLE VALUE				6.0	10.5	15.0	mg/L			
	PERMIT LIMIT				Report	Report	30	mg/l		1/7	GRAB
5-DAY 20°C BOD	SAMPLE VALUE				ND	4.8	19.0	mg/L			
	PERMIT LIMIT				Report	Report	25	mg/l		1/7	GRAB
CONDUCTIVITY (EFFLUENT)	SAMPLE VALUE				1340	1492	1830	umhos/cm			
	PERMIT LIMIT						Report	umhos/cm		A/	GRAB
CONDUCTIVITY (SOURCE WATER)	SAMPLE VALUE				1,200		2,100	umhos/cm			
	PERMIT LIMIT						Report	umhos/cm		A/	GRAB
TEMPERATURE (EFFLUENT)	SAMPLE VALUE				44.6	50.0	63.0	°F			
	PERMIT LIMIT						Report	(°F)		A/	GRAB
FLOW	SAMPLE VALUE		223,110	GPD							
	PERMIT LIMIT		REPORT	GAL/DAY						DAILY	INST
TOTAL FLOW (DRAIN)	SAMPLE VALUE		2.68	MGAL							
	PERMIT LIMIT		REPORT	MGAL						1/PERIOD	CALC

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein; and based on my inquiry of those individuals responsible for obtaining the information , I believe the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment.

BRADLEY G. STEVENS, P.E.	Brad G Stevens	701-777-5293	99/06/30
Typed or Printed Name/Title Principal Executive Officer	Signature of Principle Executive Officer or Authorized Agent	Telephone	Year/Month/Day

A/. A SAMPLE OF THE EFFLUENT AND SOURCE WATER SHALL BE COLLECTED AND ANALYZED FOR TEMPERATURE, GENERAL CHEMISTRY AND CONDUCTIVITY PRIOR TO DISCHARGE.
B/. IN ADDITION, THE DATES AND TIMES OF DISCHARGE SHALL BE REPORTED.

APPENDIX I

CITY OF DEVILS LAKE
ANNUAL WATER USE REPORTS

City of Devils Lake Daily Water Consumption Analysis - Summary

Note: All values shown, with the exception of monthly totals, are expressed as gallons x 1000

			Number of days that demand is:	
			>2.0 MGD	>2.5 MGD
1995 Data: All data	Average	856.0493	1	0
1995 Data: Jan - Dec, Adjusted				
(All values over 1100 MGD removed)	Average	801.7182		
1995 Data: January - April 12, Adjusted				
(All spikes removed)	Average	724.38		
1997 Data: All data	Average	1057.201	17	8
1997 Data: Jan - Dec, Adjusted				
(All values over 1100 MGD removed)	Average	658.8187		
1997 Data: January - April 12, Adjusted				
(All spikes removed)	Average	710.2727		
1998 Data: Jan - May, All	Average	445.0685	0	0

Assume:

Baseline Water Demand =	0.8	MGD
Nominal Peak Demand =	2.5	MGD
Days that demand is greater than baseline =	150	days
Total period of thaw =	120	days
Total 1997 Demand > baseline =	1.17E+08	gallons
Add. Water needed to meet excess demand =	778766.7	gpd
Treated FT Water needed to meet peak demand =	93.452	MG

1995 Residential Water Use, thousand gallons per day

	January	February	March	April	May	June	July	August	September	October	November	December		Overall
Total	22753	20319	23698	21295	24788	33926	25426	30492	28019	25745	28374	27623	312458	0.8560 MGD
Average	733.9677	725.6786	764.4516	709.8333	799.6129	1130.867	820.1935	983.6129	933.9667	830.4839	945.8	891.0645		856 gpd x 1000
Max	1451	860	1395	880	1510	2087	1153	1347	1707	1066	1823	1239		2087 gpd x 1000
Min	614	563	588	500	628	577	490	768	605	598	582	620		490 gpd x 1000

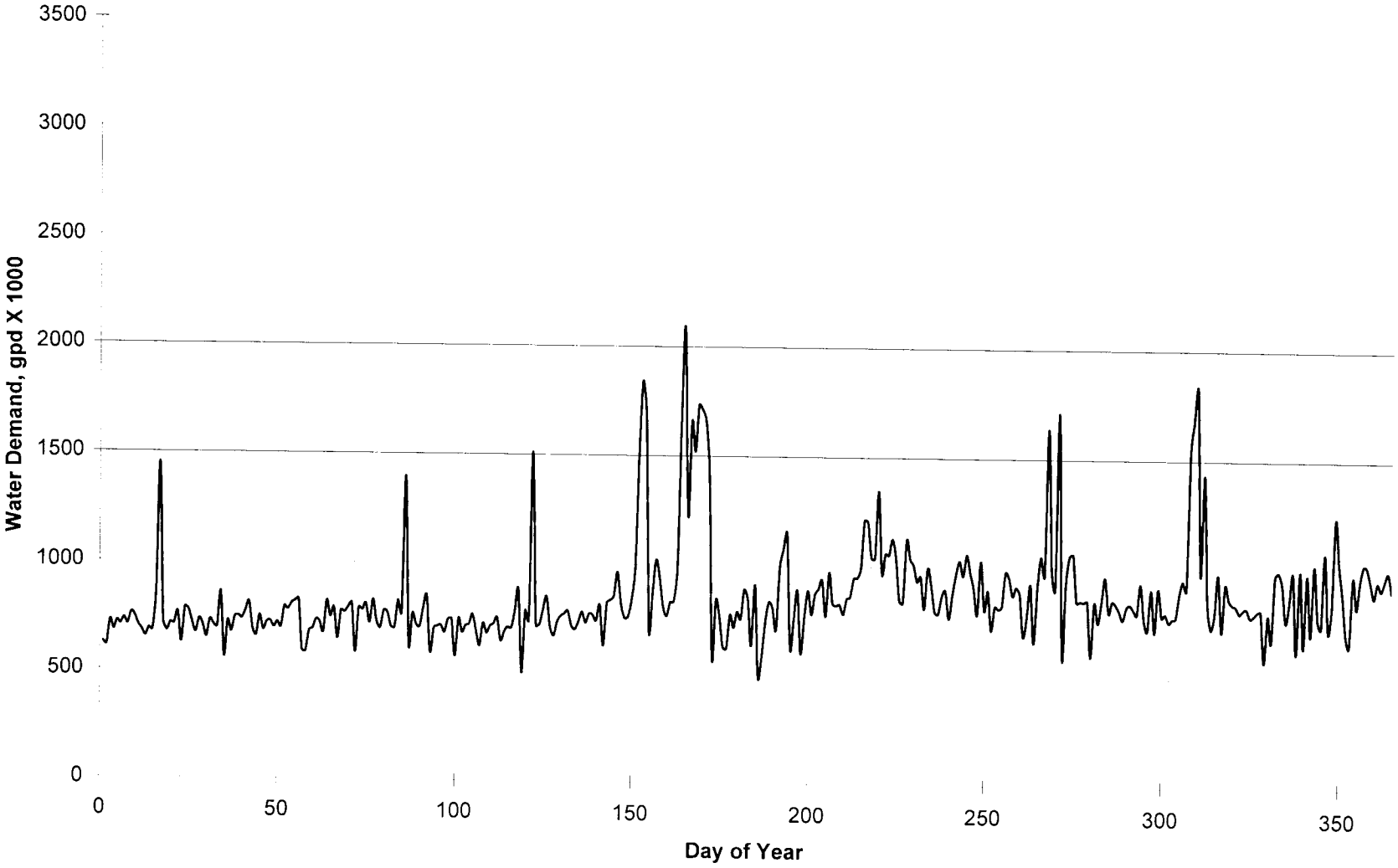
1997 Residential Water Use, thousand gallons per day

	January	February	March	April	May	June	July	August	September	October	November	December		Overall
Total	21467	19813	22429	32712	37760	56467	44898	54345	30823	7156	5540	13352	346762	0.9500 MGD
Average	692.4839	707.6071	747.6333	1090.4	1218.065	1947.138	1448.323	1753.065	1027.433	447.25	554	430.7097		1057 gpd x 1000
Max	1538	874	894	2624	1831	3048	1977	3084	2803	719	1152	655		3084 gpd x 1000
Min	412	463	584	460	888	1090	1036	810	431	169	233	177		169 gpd x 1000

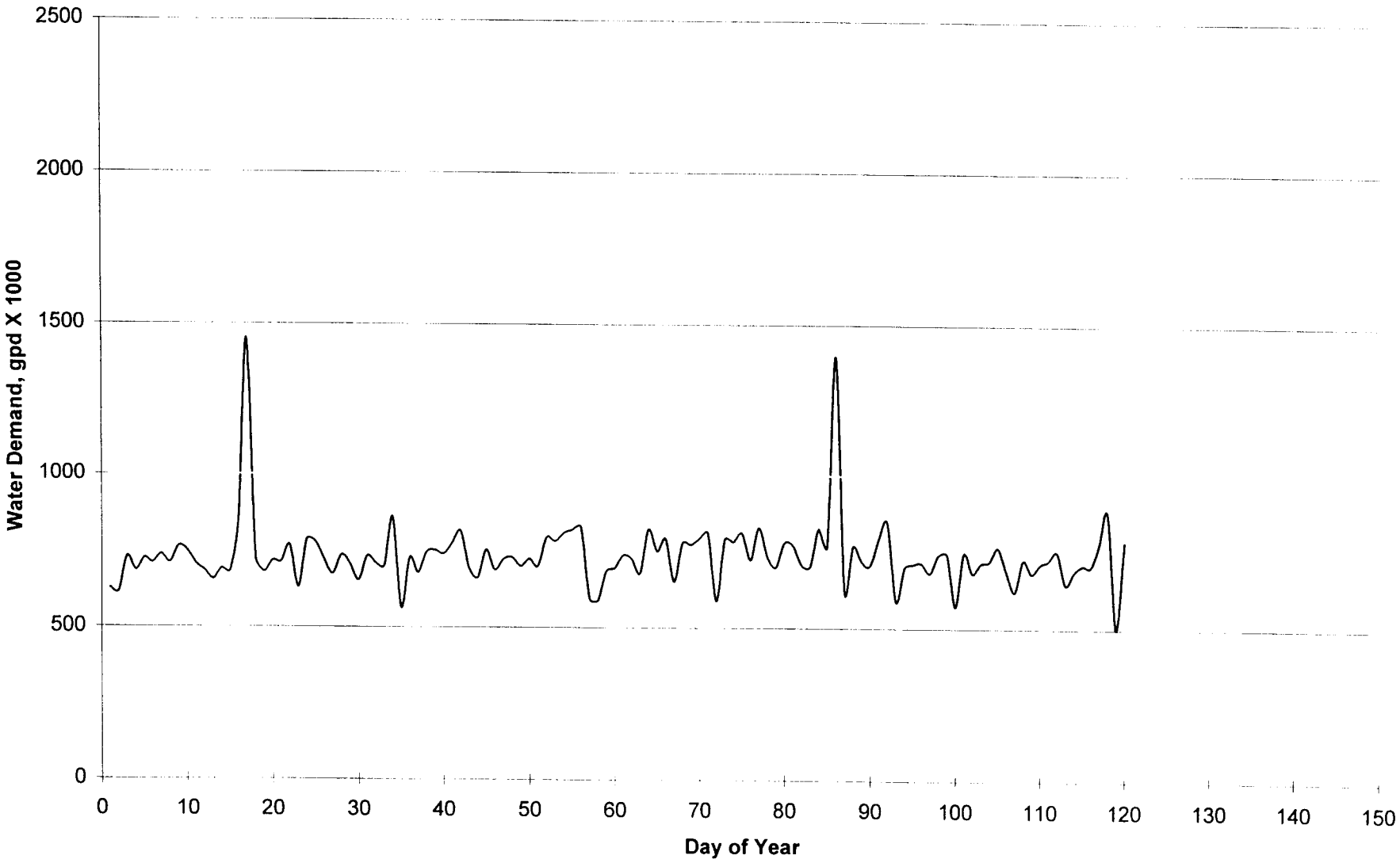
1998 Residential Water Use, thousand gallons per day

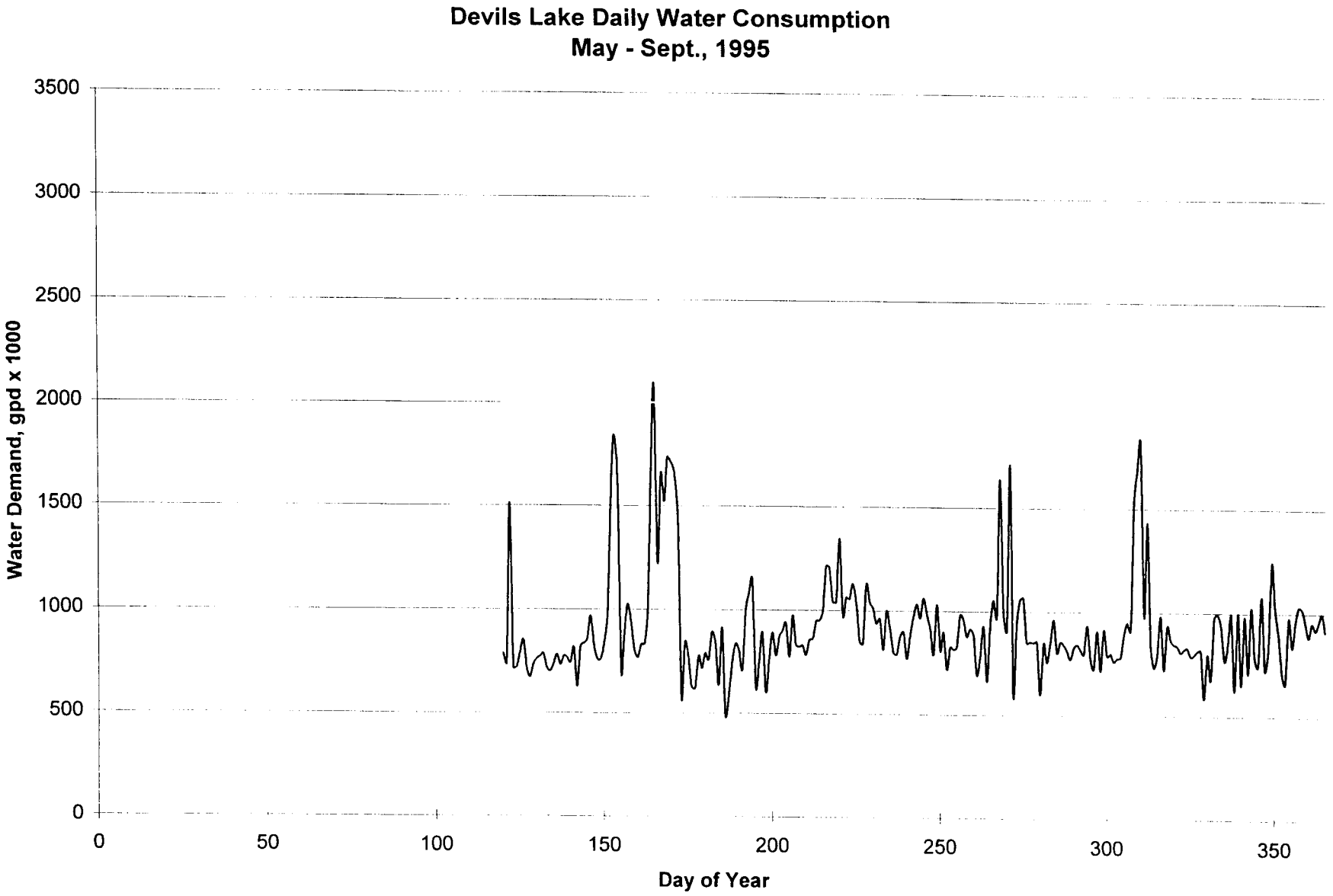
	January	February	March	April	May		Overall
Total	10637	11982	12635	11649	20194	67097	0.441428
Average	343.129	427.9286	407.5806	388.3	651.4194		445
Max	564	985	601	860	1164		1164
Min	143	149	199	132	248		132

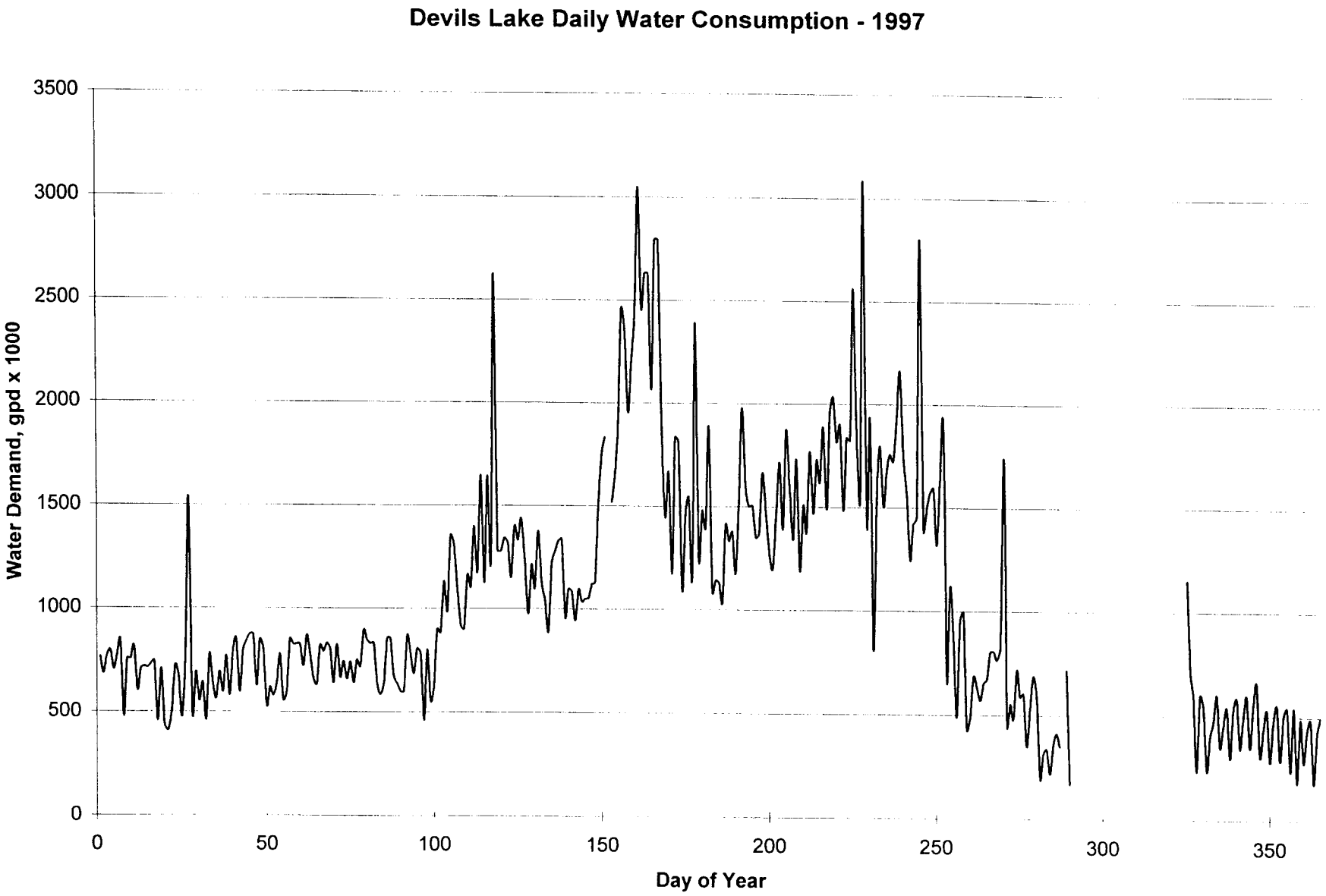
Devils Lake Daily Water Consumption - 1995

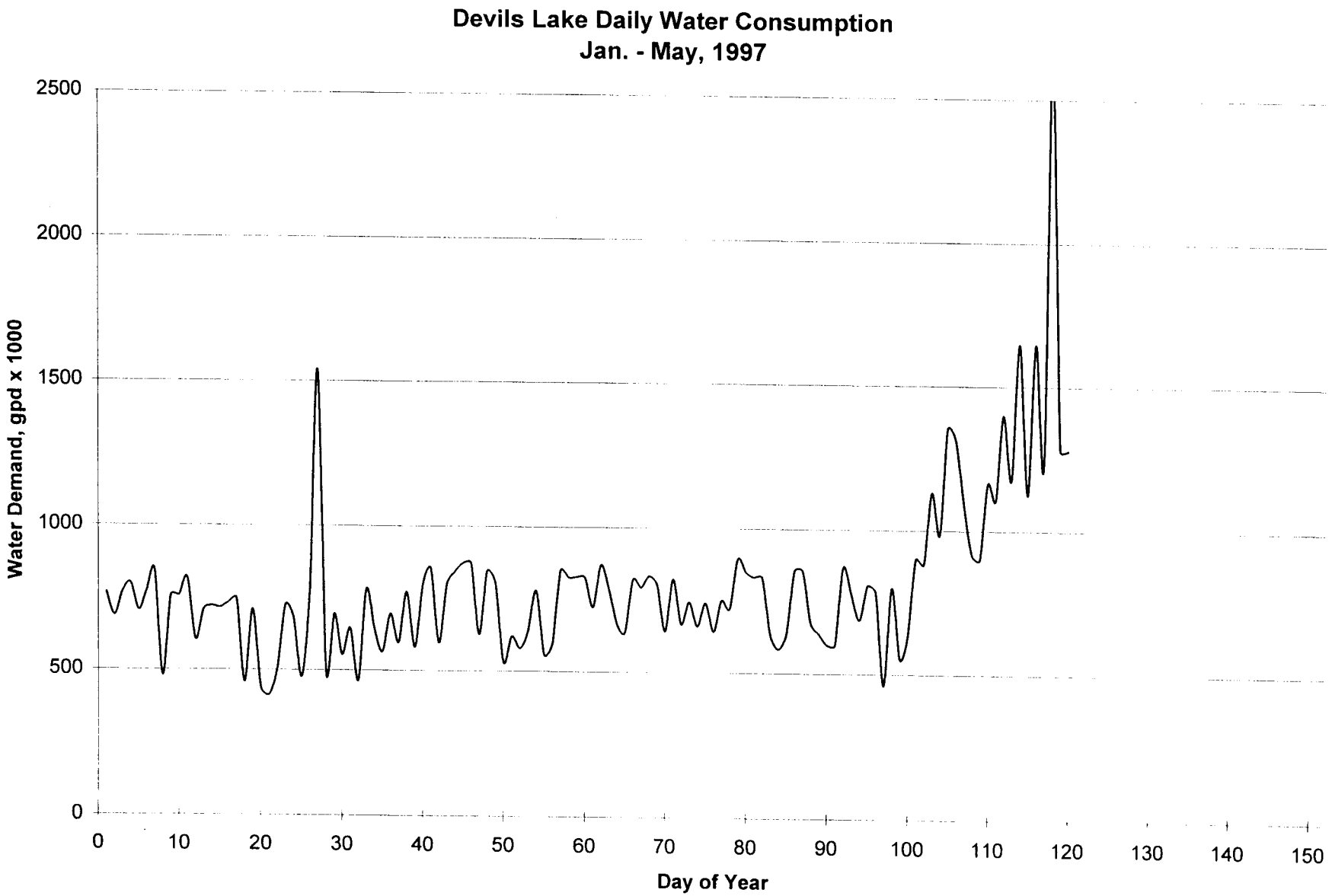


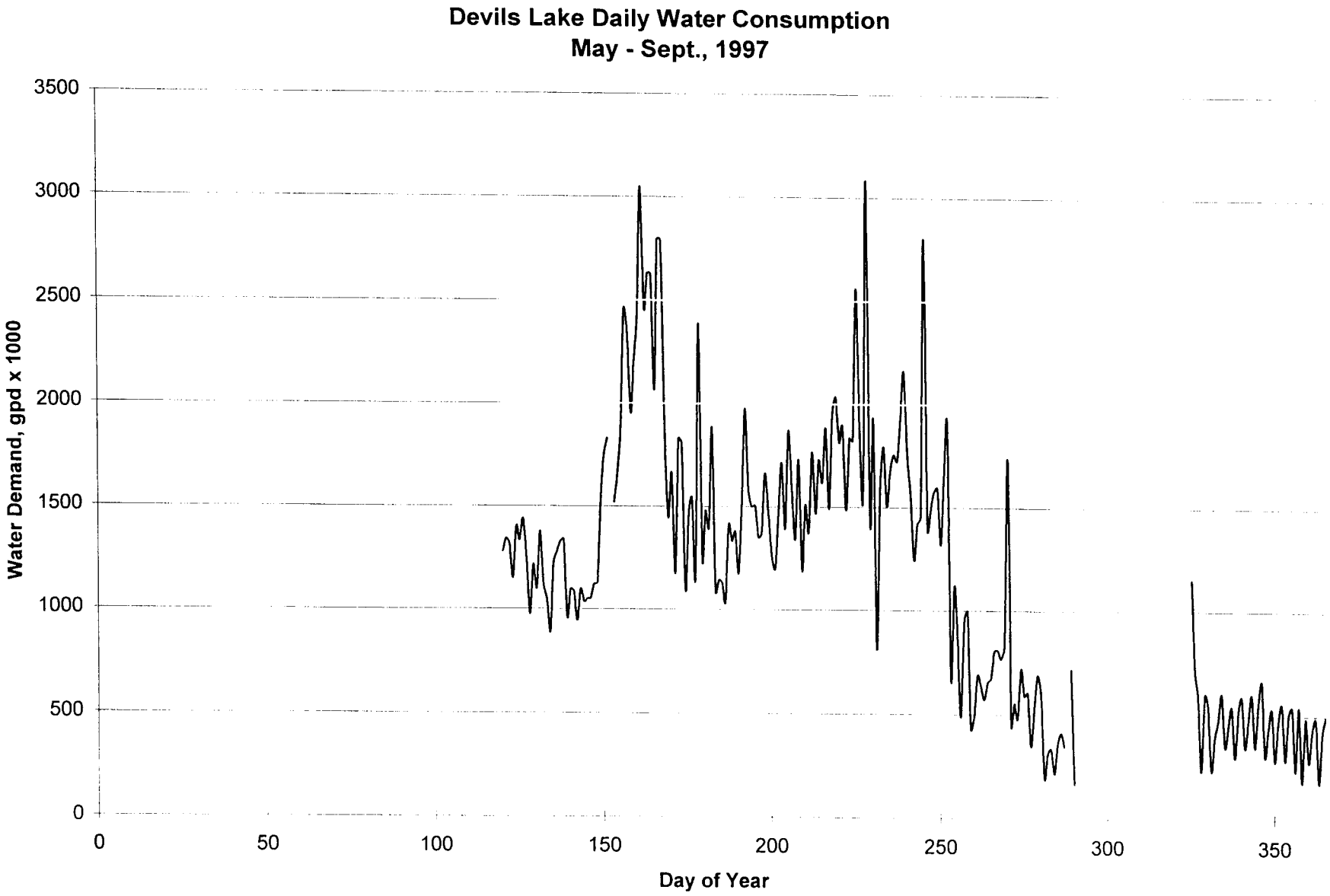
Devils Lake Daily Water Consumption
Jan. - May, 1995

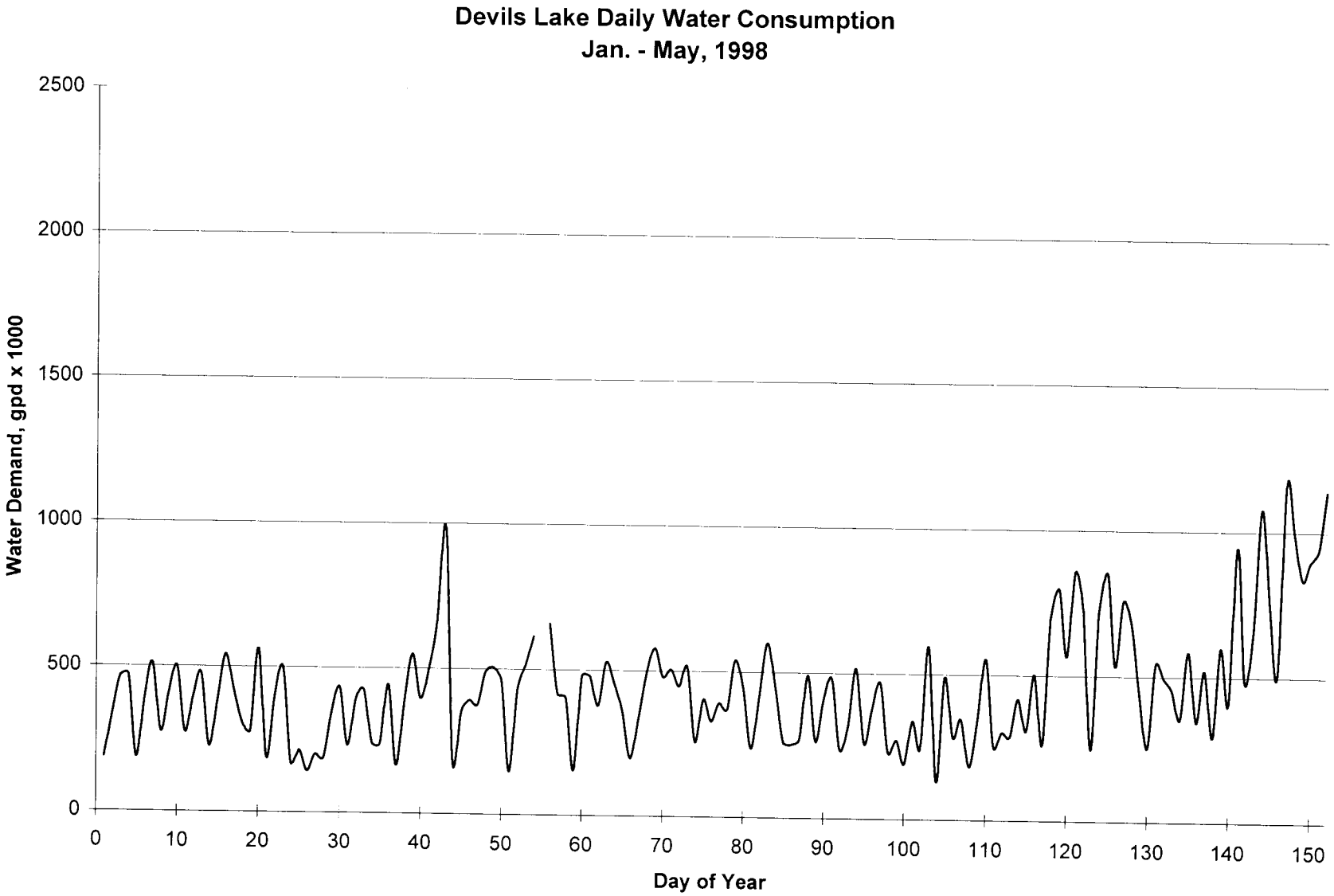



Devils Lake Daily Water Consumption
May - Sept., 1995
Water Demand, gpd x 1000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
Day of Year


Devils Lake Daily Water Consumption - 1997
Water Demand, gpd x 1000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
Day of Year


Devils Lake Daily Water Consumption
Jan. - May, 1997
Water Demand, gpd x 1000
2500
2000
1500
1000
500
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Day of Year


Devils Lake Daily Water Consumption
May - Sept., 1997
Water Demand, gpd x 1000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
Day of Year


Devils Lake Daily Water Consumption
Jan. - May, 1998
Water Demand, gpd x 1000
2500
2000
1500
1000
500
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Day of Year

1994 ANNUAL WATER USE REPORT

00774

Permit Number: 00774

DEVILS LAKE, CITY OF
PO BOX 1048

DEVILS LAKE , ND 58301

Make Name and / or Address corrections below:

Phone:

Report the total gallons per month if applicable:

JANUARY	30,928,000	JULY	22,500,000
FEBRUARY	26,234,000	AUGUST	23,355,000
MARCH	33,423,000	SEPTEMBER	24,000,000
APRIL	28,605,000	OCTOBER	23,500,000
MAY	46,653,000	NOVEMBER	20,000,000
JUNE	23,600,000	DECEMBER	36,745,000

TOTAL ANNUAL USE 332,543,000

POPULATION SERVED 7,782

NUMBER OF CONNECTIONS SERVED 2270

I. INFORMATION ABOUT WELLS, PUMPS, OR POINTS OF DIVERSION

Report the following information for EACH point of diversion

Point of Diversion
NW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water
Pumping Rate: 600 (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)
Total Water Use from this Point of Diversion: 35%

Point of Diversion
NW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water
Pumping Rate: 500 (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)
Total Water Use from this Point of Diversion: 20%

Please return to:
North Dakota State Water Commission
State Office Building
900 East Boulevard
Bismarck, North Dakota 58505
Phone: (701) 328-2754

Signature

Date 2-27-94

Point of Diversion
SW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water _____
Pumping Rate: 350 (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)
Total Water Use from this Point of Diversion: 25%

Point of Diversion
NW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water _____
Pumping Rate: 356 (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)
Total Water Use from this Point of Diversion: 20%

1996 ANNUAL WATER USE REPORT

Return this form even if no water was used

00774

Permit Number: 00774

DEVILS LAKE, CITY OF
PO BOX 1048

DEVILS LAKE , ND 58301

Make Name and / or Address corrections below:

Phone:

Report the total gallons per month if applicable:

JANUARY	29,926,000	JULY	26,739,000
FEBRUARY	27,319,000	AUGUST	28,267,000
MARCH	32,639,000	SEPTEMBER	26,529,000
APRIL	29,338,000	OCTOBER	25,619,000
MAY	34,619,000	NOVEMBER	23,342,000
JUNE	29,320,000	DECEMBER	31,827,000

TOTAL ANNUAL USE 345,484,000

POPULATION SERVED 7,782

NUMBER OF CONNECTIONS SERVED 2,233

I. INFORMATION ABOUT WELLS, PUMPS, OR POINTS OF DIVERSION

Report the following information for EACH point of diversion

Point of Diversion
NW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water
Pumping Rate: 600GPM (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)
Total Water Use from this Point of Diversion: 30%

Point of Diversion
NW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water
Pumping Rate: 500 GPM (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)
Total Water Use from this Point of Diversion: 25%

Please return to:
North Dakota State Water Commission
State Office Building
900 East Boulevard
Bismarck, North Dakota 58505
Phone: (701) 328-2754

Signature

Date 1-13-97

Point of Diversion
SW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water _____
Pumping Rate: 350 GPM (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)
Total Water Use from this Point of Diversion: 25 %

Point of Diversion
NW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water _____
Pumping Rate: 350 GPM (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)
Total Water Use from this Point of Diversion: 20 %

1997 ANNUAL WATER USE REPORT

Return all pages of this form even if no water was used

00774

Permit Number: 00774

DEVILS LAKE, CITY OF
PO BOX 1048

DEVILS LAKE , ND 58301

Make Name and / or Address corrections below:

Phone:

Report the total gallons per month if applicable:

Meter Down EST & USAGE.

JANUARY	29,829,000	JULY	27 892 000
FEBRUARY	26,420,000	AUGUST	29 468 000
MARCH	26,163,000	SEPTEMBER	28,572,000
APRIL	27,398,000	OCTOBER	25,722,000
MAY	30,879,000	NOVEMBER	24,632,000
JUNE	39,862,000	DECEMBER	29,323 000

TOTAL ANNUAL USE 346,160 000

POPULATION SERVED 7,782

NUMBER OF CONNECTIONS SERVED 2,250

I. INFORMATION ABOUT WELLS, PUMPS, OR POINTS OF DIVERSION

Report the following information for EACH point of diversion

Point of Diversion
NW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water
Pumping Rate: 600 GPM (Circle: Barrels, Acre-Feet, Cubic Feet, (Gallons) **PER** (Second, ~~Minute~~, Hour, Day)
Total Water Use this Point of Diversion: 30 % (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)

Point of Diversion
NW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water
Pumping Rate: 500 GPM (Circle: Barrels, Acre-Feet, Cubic Feet, (Gallons) **PER** (Second, (Minute) Hour, Day)
Total Water Use this Point of Diversion: 25 % (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)

Please return to:
North Dakota State Water Commission
State Office Building
900 East Boulevard
Bismarck, North Dakota 58505
Phone: (701) 328-2754

Signature mce

Date 3/2/98

cc: ENGR.
C. TY Comm.

Point of Diversion
SW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water _____
Pumping Rate: 350 GPM (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons) **PER** (Second, Minute, Hour, Day)
Total Water Use this Point of Diversion: 25 % (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)

Point of Diversion
NW 1/4 NE 1/4 Sec. 29 Twp. 151 Rng. 063
Water Source: GroundWater X Surface Water _____
Pumping Rate: 350 GPM (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons) **PER** (Second, Minute, Hour, Day)
Total Water Use this Point of Diversion: 20 % (Circle: Barrels, Acre-Feet, Cubic Feet, Gallons)

APPENDIX J

CITY OF DEVILS LAKE MUNICIPAL RAW WATER ANALYTICAL RESULTS

North Dakota State Consolidated Laboratories
North Dakota State Department of Health
5/11/89
Ramsey County

Log Number: 89-N525

Date Collected: 4/26/89
Township:
Section:
Source: Raw Water Well # 10

Date Received: 4/26/89
Range:
Owner:

Comments:

Devils Lake Water Dept.
C/O Jim Moe
Box 1048
Devils Lake, ND 58301

Chemical Analysis of Water

Conductivity	849.0	umhos/cm	
Total Dissolved Solids(C)	515.	mg/l	Satisfactory
Total Hardness (as CaCO3)	363.	mg/l	High
Total Alkalinity (CaCO3)	326.	mg/l	Satisfactory
pH	7.7		
Iron (Fe)	0.184	mg/l	Satisfactory
Manganese (Mn)	0.904	mg/l	High
Calcium (Ca)	108.	mg/l	
Magnesium (Mg)	22.7	mg/l	
Sodium (Na)	59.4	mg/l	Fairly Low
Potassium (K)	5.00	mg/l	
Carbonate (CO3)	0.	mg/l	
Bicarbonate (HCO3)	398.	mg/l	
Sulfate as (SO4)	94.	mg/l	Fairly Low
Chloride	30.1	mg/l	Fairly Low
Fluoride (F)	0.1	mg/l	
Nitrate (as N)	0.0	mg/l	Satisfactory
Turbidity	< 1	NTU	
Percent Sodium	26.2	%	
Sodium Adsorption Ratio	1.36		

This water would cause staining of laundry and plumbing fixtures due to its high manganese content.

This water is classified C4-S1 for irrigation.
Contact your county agent for more information.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For any further information, contact:
North Dakota State Department of Health
Division of Water Supply and Pollution Control
Box 5520, Bismarck, ND 58502-5520 (701) 224-2354

Per. Ken Kary Chemist

North Dakota State Consolidated Laboratories
North Dakota State Department of Health
5/11/89
Ramsey County

Log Number: 89-N522

Date Collected: 4/26/89 Date Received: 4/26/89
Township: Range:
Section: Owner:
Source: Raw Water City Well # 11

Comments:

Devils Lake Water Dept.
C/O Jim Moe
Box 1048
Devils Lake, ND 58301

Chemical Analysis of Water

Conductivity	646.0	umhos/cm	
Total Dissolved Solids(C)	376.	mg/l	Fairly Low
Total Hardness (as CaCO3)	241.	mg/l	Average
Total Alkalinity (CaCO3)	310.	mg/l	Satisfactory
pH	7.7		
Iron (Fe)	0.143	mg/l	Satisfactory
Manganese (Mn)	0.757	mg/l	High
Calcium (Ca)	71.3	mg/l	
Magnesium (Mg)	15.3	mg/l	
Sodium (Na)	60.0	mg/l	Satisfactory
Potassium (K)	4.50	mg/l	
Carbonate (CO3)	0.	mg/l	
Bicarbonate (HCO3)	378.	mg/l	
Sulfate as (SO4)	28.	mg/l	Low
Chloride	10.9	mg/l	Low
Fluoride (F)	0.2	mg/l	
Nitrate (as N)	0.0	mg/l	Satisfactory
Turbidity	< 1	NTU	
Percent Sodium	35.0	%	
Sodium Adsorption Ratio	1.68		

This water would cause staining of laundry and plumbing fixtures due to its high manganese content.

This water is classified C4-S1 for irrigation.
Contact your county agent for more information.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For any further information, contact:
North Dakota State Department of Health
Division of Water Supply and Pollution Control
Box 5520, Bismarck, ND 58502-5520 (701) 224-2354

Per. Ken Kary Chemist

North Dakota State Consolidated Laboratories
North Dakota State Department of Health
5/11/89
Ramsey County

Log Number: 89-N523

Date Collected: 4/26/89
Township:
Section:
Source: Raw Water Well # 12

Date Received: 4/26/89
Range:
Owner:

Comments:

Devils Lake Water Dept.
C/O Jim Moe
Box 1048
Devils Lake, ND 58301

Chemical Analysis of Water

Conductivity	966.0	umhos/cm	
Total Dissolved Solids(C)	592.	mg/l	Satisfactory
Total Hardness (as CaCO3)	422.	mg/l	High
Total Alkalinity (CaCO3)	365.	mg/l	Satisfactory
pH	7.6		
Iron (Fe)	0.892	mg/l	High
Manganese (Mn)	1.18	mg/l	High
Calcium (Ca)	126.	mg/l	
Magnesium (Mg)	26.1	mg/l	
Sodium (Na)	58.8	mg/l	Fairly Low
Potassium (K)	5.50	mg/l	
Carbonate (CO3)	0.	mg/l	
Bicarbonate (HCO3)	446.	mg/l	
Sulfate as (SO4)	121.	mg/l	Fairly Low
Chloride	34.5	mg/l	Fairly Low
Fluoride (F)	0.1	mg/l	
Nitrate (as N)	0.0	mg/l	Satisfactory
Turbidity	5.00	NTU	
Percent Sodium	23.2	%	
Sodium Adsorption Ratio	1.24		

This water would cause staining of laundry and plumbing fixtures due to its high iron and manganese content.

This water is classified C4-S1 for irrigation.
Contact your county agent for more information.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For any further information, contact:
North Dakota State Department of Health
Division of Water Supply and Pollution Control
Box 5520, Bismarck, ND 58502-5520 (701) 224-2354

Per. Ken Kary Chemist

APPENDIX K

FREEZE-THAW COMMERCIAL FACILITY DESIGN AND CAPITAL COST

FREEZE–THAW COMMERCIAL FACILITY DESIGN AND CAPITAL COST

PLANT SIZE

The City of Devils Lake's 1997 residential water use was used to estimate the FT commercial plant size that would be necessary to meet peak demand requirements. These data are summarized in appendix H. Based upon the recommendation of the city engineer, 800,000 gpd was considered baseline water demand. It was found that during 150 days in 1997, water demand exceeded baseline. These days were primarily during the period of April through September. The total demand in excess of baseline in 1997 was 117 Mgal, which averages to be 778,767 gpd. The FT commercial plant was sized to provide water for 120 days of this period. Thus the size of the FT commercial plant was set to provide 93.45 Mgal/yr of TW. The performance of the FT demonstration plant was then used to estimate the remaining process flows. The demonstration plant performance is summarized below in table K-1.

Table K-1. FT Demonstration Performance

	Gallons	Percent of feed
Feed	4,399,316	
Concentrated brine	123,701	2.8
Nondischargable intermediate	253,507	5.8
Total requiring disposal	377,208	8.6
Dischargeable intermediate	182,583	4.2
Treated water	3,684,290	83.8
Losses	155,235	3.5

Considering the demonstration plant TW yield and commercial plant production rate, the commercial plant feed rate was determined:

$$\text{Commercial Plant Feed Rate} = \frac{93.45 \text{ Mgal/yr}}{0.838} = 111.52 \text{ Mgal/yr}$$

Similarly, brine and intermediate disposal requirements are as follows:

Total Requiring Disposal = 111.52 Mgal/yr × 0.086 = 9.59 Mgal/yr

Dischargeable intermediate and losses would be as follows:

Dischargeable Intermediate = 111.52 Mgal/yr × 0.042 = 4.68 Mgal/yr

Losses = 111.52 Mgal/yr × 0.035 = 3.90 Mgal/yr

In summary, the commercial FT plant performance is estimated to be as follows:

	Mgal/yr
Feed	111.52
Brine disposal	9.59
Return to lake	4.68
Treated water	93.45
Losses	3.90

PLANT DESIGN

Freezing Pad Design

Three processing and storage vessels are required for the FT commercial facility: a FP, a brine storage pond, and a TW storage pond. The FP is sized based upon the demonstration plant feed volume and the area of spray coverage in the FP. In the design of the FP, it is necessary to leave some distance around the perimeter without sprays in order to prevent sprayed water from being carried outside the FP by wind. In the demonstration operation, it was found that 80 ft was necessary to contain sprayed water in the strong winds typical of northeastern North Dakota, and three of the four spray laterals were operated. The area of spray cover was 80 ft × 120 ft in each of the demonstration FP. The total area of spray coverage was 0.44 acres. Considering the volume of feed to the FP of 4,399,316 gal, the water processed per acre of spray coverage was 9,980,300 gal/acre of sprays. The commercial FT facility feed rate of 111.52 Mgal would then require 11.17 acres of sprays. Considering the size of the property for the commercial facility (1950 ft × 1135 ft), the area of spray coverage was sized to be 828 ft × 588 ft (11.18 acres). Considering the 80 ft without spray coverage around the perimeter of the sprays, the resulting FP size is 988 ft × 748 ft (25.47 acres). The interior and exterior berm slopes of the freezing pad are 3:1 horizontal to vertical.

The storage capacity of the FP is 25.47 Mgal. The FP is lined with an 18-mil synthetic liner similar to those used in the demonstration plant. The FP is equipped with four 12"-diameter drainage laterals under the pad feeding two 4-ft-diameter pump sumps. Four 40-hp pumps, two per sump, are provided for up to 5600 gpm (at 50 ft of head) of spray capacity.

Demonstration plant sprays were typically operated in the range of 10 to 25 gpm, with 40-ft spacing between sprays. The commercial plant is designed to provide 70 gpm to 63 spray nozzles on nominally 100-ft spacing. The sprays are fed by a 10"-diameter high-density polyethylene (HDPE) header feeding seven 6"-diameter spray laterals each having nine sprays. Details regarding the FP and related piping and instruments are provided in Drawings 2, 9, 10, 12, 13, and 14 in appendix L.

Brine Storage Pond Design

The brine pond is designed to store brine produced for evaporative disposal during the summer months. In addition to the brine pond, demonstration plant FP FP1 and FP2 will also be used for brine storage and later for evaporation. Each of the demonstration plant FP has the capacity to store 700,000 gallons of water for a total of 1.4 Mgal of storage capacity.

The brine pond is sized at 514 ft x 304 ft x 13 ft deep (3.59 acres). It has the capacity to hold 8.92 Mgal with a 10-ft water depth and 3-ft vertical freeboard. Thus the FT facility has the capacity to store up to 10.32 Mgal of brine, if necessary.

The brine pond is also constructed with an 18-mil synthetic liner. The brine pond has a 40-hp pump installed in a 4-ft-diameter sump 15 ft deep. The sump is fed by a 12"-diameter HDPE pipe 50 ft long, originating in the bottom of the brine pond. The pond is fed by an 8"-diameter HDPE pipe 50 ft long that is also installed in the bottom of the pond.

The demonstration plant FP and the commercial plant FP will be used to evaporate the brine during the summer months. Drawings 4, 19, 20, and 21 provide details of the brine pond and piping design (appendix L).

TW Storage Pond Design

As previously discussed, the commercial FT plant is designed to provide at least 93.45 Mgal/yr of TW. Based upon demonstration plant performance, the TW harvest is assumed to occur in March through May. Based upon 1997 Devils Lake residential water usage, 290,000 gpd above baseload will be required in the month of April, and 418,000 gpd will be required in May. Thus 21.66 Mgal will be removed from the system during these months, leaving 71.79 Mgal requiring onsite storage until it is consumed.

Based upon the demonstration plant results, the TW pond will not be synthetically lined. Instead, it will be clay-lined. The TW storage pond is shaped to fit the space available on the property (see Drawings 1 and 3 in appendix L). The pond is sized at 14.86 acres. It is constructed to have a depth of 15 ft, with 3:1 (horizontal to vertical) interior and exterior berm slopes. The pond has a storage capacity of 55.54 Mgal, with a 12-ft water depth and 3-ft vertical freeboard. During the final stages of the ice melt, the TW pond should fill, and approximately 16.25 Mgal of melt would remain. At such time as this may occur, the 25.47 Mgal of storage capacity in the FP will be used to retain the TW.

The TW pond is equipped with a 40-hp pump installed in a 4-ft-diameter sump 17 ft deep. The sump is fed by a 12"-diameter HDPE pipe 60 ft long. The pond is fed by an 8"-diameter HDPE pipe 60 ft long. Details regarding the design of the TW storage pond and related piping are provided in Drawings 3, 15, 16, 17, and 18 in appendix L.

Facility Feed System Design

The FT facility will be fed with water from Creel Bay of Devils Lake. A pump sump and pump will be installed in Creel Bay. A 4-ft-diameter concrete pump sump 15 ft deep will be installed 11 ft off the shoreline in Creel Bay. The sump will be fed by a 12"-diameter HDPE pipe extending 350 ft into Creel Bay. A 40-hp pump will be used to feed the facility. The pump is capable of providing 1400 gpm at 50 ft of head. Water is pumped from Creel Bay through an 8"-diameter HDPE pipe 1058 ft long to the two FP sumps. The inlet's FP sumps are located at an elevation 14.5 ft below the outlet of the pump in Creel Bay. The pressure drop in the piping with 1400 gpm flow is estimated to be less than 15 psi (35 ft). The pressure drop in the 350-ft-long suction line is estimated to be less than 1 psi (2 ft) at 1400 gpm. The feed pump must be operated for 55 days/yr at 1400 gpm to provide the required flow to the FT facility. If the FP is filled prior to winter operation, the feed pump will be required to operate 433 days. Drawings 6, 7, and 8 in appendix L provide details of the design of the feed system.

Polishing Plant Design

Treated water produced from the FT facility will be pumped through a polishing plant prior to use. The polishing plant will provide chemical addition, flocculation, clarification, and filtration. The unit is a packaged unit built by Pacific Keystone Technologies, Inc., and is sized for 1.0 Mgal/day. Waste (sludge) from the polishing plant will be pumped to the demonstration FP and disposed of with evaporated solids. Manufacturer literature regarding the polishing plant is provided in appendix M.

Buildings and Electrical Service

The FT facility will require six new buildings. Building 1 is located on Creel Bay to house the pump supplying feedwater to the facility. The building is constructed of wood and has interior dimensions of 12 ft × 12 ft × 7 ft high. The building will have a 50-KVA, 460-V 3-phase electrical service and a 15-KVA, 460-V 3-phase/240-V 1-phase transformer. A wire run of 826 ft will be required to service the building. Drawings 1 and 7 in appendix L provide details regarding Building 1.

Buildings 2 and 3 are located on the north berm of the FP. The buildings are constructed of wood, with interior dimensions of 14 ft × 30 ft × 7 ft high. These buildings will each have a 112-KVA, 460-V 3-phase electrical service and a 25-KVA, 460-V 3-phase/240-V 1-phase transformer. Wire runs to the buildings will be 600 ft to Building 2 and 775 ft to Building 3. Details regarding Buildings 2 and 3 are provided in Drawings 1 and 12 in appendix L.

Building 4 is also located on the north berm of the FP. It provides equipment for the receipt and transfer of TW. It is constructed of wood and has interior dimensions of
14 ft × 14 ft × 7 ft high. The building will have a 50-KVA, 460-V 3-phase electrical service with a 15-KVA, 460-V 3-phase/240-V 1-phase transformer. A wire run of 975 ft is required to provide electrical service to Building 4. Details regarding Building 4 are provided in Drawings 1 and 17 in appendix L.

Building 5 is located on the south berm of the brine pond. It provides equipment for the receipt and transfer of brine. The building is constructed of wood and has interior dimensions of 14 ft × 14 ft × 7 ft high. The building will have a 50-KVA, 460-V 3-phase/240-V 1-phase transformer. The wire run to the building will be 410 ft. Details regarding Building 5 are provided in Drawings 1 and 20 in appendix L.

The office and polishing plant building provides space for plant control and office along with the space required for the polishing plant. The building is constructed of steel with dimensions of 40 ft × 60 ft × 12 ft high. The building will have a 75-KVA, 240-V 1-phase electrical service. The main plant power service will be located next to this building so the wire run will be minimal. The building will be heated using propane and will have two 200,000-Btu/hr heaters. The facility will have a septic system and utilize lake water. The building will not have potable water.

The main facility power service located next to the office and polishing plant building will be 400-KVA, 460-V 3-phase. A wire run of 938 ft will be required for the main power service.

ECONOMIC ANALYSIS

Economic analysis of the commercial FT facility at Devils Lake involves determination of the installed capital cost and annual operating expenses and water treatment costs for the facility.

Feedwater Delivery, Collection, and Transmission

Details can be seen in Drawings 6, 7, and 8 in appendix L.

a. Excavation of trench 8 ft below lake level to 70 ft from lake shoreline.
   Note: To be conducted in January or February.

Volume Excavated	581 yd^3
Cost	$1685
Data:	
Trench Width	4 ft
Trench Depth	8 ft
Trench Slope	3:1 (horizontal to vertical)
Trench Length	70 ft
Excavation Cost	$2.90 yd^3

b. Placement of suction line, discharge line, and pump sump.

Cost:	
Materials	$5,849
Labor	528
Heavy Equipment	225
Total Cost	$6,602

Data:	
6"-diameter HDPE	75 ft
6"-diameter HDPE	$3.70/ft
12"-diameter HDPE	350 ft
12"-diameter HDPE	$13.03/ft FOB-DL
Pump sumps required	1
Pump sump base (3 ft high)	$339 FOB-DL
Pump sump risers	12 ft
Pump sump risers	$56/ft FOB-DL
Labor (apprentice)	3 worker-days
Labor (apprentice)	$176/worker-day
Cat loader	3 hr
Cat loader	$75/hr

c. Earthwork for Building 1.

Soil placement and compaction	233 yd^3
Note: Use earth from trench excavation.	
Riprap required	88 tons
Cost	$3316
Data:	
Pad height	6.5 ft
Pad top size	22 ft x 22 ft
Pad slope	3:1 (horizontal/vertical)
Trench width	4 ft
Trench depth	8 ft
Trench length from pad slope	12.5 ft
Riprap thickness	1 ft
Riprap bulk density	65 lb/ft^3
Riprap	$30/ton

d. Concrete Pad for Building 1.

Materials	$490
Labor	352
Total cost	$842
Data:	
Concrete pad	22 ft x 22 ft x 4" thick
Concrete	$72/$yd^3$
Rebar	$.12/$ft^2$
Labor (apprentice)	2 worker-days
Labor (apprentice)	$176 /worker-day

e. Building 1.

Cost	$4,320
Data:	
Building 1	12 ft x 12 ft x 7 ft high
Building cost	$30/ft^2

f. Fence.

Materials	$465
Labor	176
Total cost	$641
Data:	
Length of fence	69 ft x 6 ft high
Fence cost	$4.10/ft
16-ft gate	1 required
16-ft gate	$120
3-ft gate	1 required
3-ft gate	$62
Labor (apprentice)	1 worker-day
Labor (apprentice)	$176/worker-day

g. Building 1 – Pump, Piping, and Instruments.

Materials	$20,226
Labor	1,760
Total cost	$21,986

	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE pipe	6"	3.70/ft	10	37
	8"	6.02/ft	60	361
Adapters	6"	30.00/ea	1	30
Butterfly valves	6"	201.00/ea	1	201
	8"	365.00/ea	8	2,920
Flanges sets (w/bolts)	6"	88.00/ea	2	176
	8"	156.00/ea	8	1,248
Miscellaneous:				
Sample port – ½" (complete)		15.00/ea	2	30
TC Port ¼" (complete)		15.00/ea	1	15
Pressure gauge (complete)		68.00/ea	1	68
EC meter		501.00/ea	1	501
Flowmeter		1,014.00/ea	2	2,028
Pump – 40 hp		10,624.00/ea.	1	10,624
Pump control panel		1,900.00/ea.	1	1,900
TC with display		87.00/ea	1	87
Total materials				20,226
Labor (apprentice)		176.00/day	10	1,760
Total labor				1,760
Total cost				21,986

h. Building 1 – Electrical.

Materials	$23,011
Labor	2,080
Trenching	1,083
Total cost	$26,173

	Unit cost, $	Units required	Extended cost, $
Electrical:			
30-ft light poles installed	135.00/ea	1	135
High-voltage pwr ser. Wire	15.59/ft	826	12,876
1 ea.–50-KVA, 460-VAC service,15-KVA Transformer to 240-VAC, and 110-VAC Lights and recept.	10,000.00/ea	1	10,000
Total electrical materials			23,011
Electrical labor:			
Apprentice	176.00/day	5	880
Journeyman	240.00/day	5	1,200
Total electrical labor			2,080
Trenching for wire installation			
Trenching – high-voltage	1.25/ft	786	983
Trenching – berm	2.50/ft	40	100
Total trenching cost			1,083
Total electrical cost			26,173

I. Line to/from Buildings 2 and 3 and Building 1.

Materials	$6,381
Labor	1,760
Heavy equipment	1,168
Total cost	$9,309

Data:	
8"-diameter HDPE pipe	1,060 ft
8"-diameter HDPE pipe	$6.02/ft
Trac hoe	8 hours
Trac hoe	$146.00/hr
Labor (apprentice)	10 worker-days
Labor (apprentice)	$176/worker-day

Total cost of feedwater delivery, collection, and transmission:	
Trench excavation	$ 1,685
Placement of suction line, discharge line, and pump sump	6,602
Earthwork for building 1	3,316
Concrete pad for building 1	842
Building 1	4,320
Fence	641
Building 1 – pump, piping, and instruments	21,986
Building 1 – electrical	26,173
Line to/from buildings 2 and 3 and building 1	9,309
Total cost	$74,874

Raw Water Pretreatment

There is no raw water pretreatment in the FT process.

FT Plant and Controls

The installed capital costs of the FT process are estimated below. These costs include the cost of the FP; TW storage pond; brine storage pond; Buildings 2, 3, 4, and 5, including the piping and instruments; and the piping of the transfer lines.

a. Freezing pads, TW storage pond, and brine storage pond. Details can be seen in Drawings 2, 3, and 4 in appendix L.

Freezing Pads (excluding berm construction)

Excavation and compaction	$291,234
Liner	168,364
Liner seaming crew	18,250
Labor	1,760
Total cost	$479,607

TW Storage Pond (excluding berm construction)

Excavation and compaction	$620,327
Total Cost	$620,327

Brine Storage Pond (excluding berm construction)

Excavation and compaction	$113,469
Liner	37,312
Liner seaming crew	3,650
Labor	704
Total Cost	$155,135

The total cost of the FP, TW storage pond, and brine pond (excluding berm construction) is $1,255,069.

Berm Construction

Excavation and compaction	$141,692
Total Cost	$141,692
Data:	
Excavation/compaction	$2.90/yd^3
FP1 liner	1,003 ft × 763 ft
BP liner	530 ft × 320 ft
Liner	$0.22/ft^2
Liner seaming crew	4 acres/day
Liner seaming crew	$1825/day
Labor to help lining crew	14 worker-days
Labor	$176/day

b. Freezing Pad Spray System. Details can be seen in Drawing 9 in appendix L.

Materials	$38,716
Labor	3,520
Total cost	$42,236

	Materials – Piping and Instruments			
	Dia	Unit cost, $	Units required	Extended cost, $
HDPE pipe				
	6"	3.70/ft	6,500	24,050
	10"	9.05/ft	600	5,430
Sch. 80 PVC pipe	2"	0.50/ft	2,520	1,260
Sch. 80 PVC FNPT x soc	2"	4.58/ea	650	2,977
Sch. 80 PVC NPT x soc	2"	3.49/ea	650	2,269
2"-NPT spray nozzles		42.00/ea	65	2,730
Total materials				38,716
Labor (apprentice)		176.00/day	20	3,520
Total labor				3520

c. Freezing Pad Outlet. Details can be seen in Drawing 10 in appendix L.

Materials	$58,635
Labor	3,520
Heavy equipment	3,504
Total cost	$65,659

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE pipe				
	12"	13.03/ft	4500	58,635
Total materials				58,635
Heavy equipment:				
Trac hoe		146.00/hr	24	3,504
Total heavy equipment				3,504
Labor (apprentice)		176.00/day	20	3,520
Total labor				3,520

d. Commercial Plant/Demonstration Plant Connection. Details can be seen in Drawing 11 in appendix L.

Materials	$1,056
Labor	352
Heavy equipment	1,168
Total cost	$2,576

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE pipe:				
	4"	1.92/ft	550	1,056
Total materials				1,056
Heavy equipment:				
Trac hoe		146.00/hr	8	1,168
Total heavy equipment				1,168
Labor (apprentice)		176.00/day	2	352
Total labor				352

e. Buildings 2 and 3 Inlets, Discharges, Pump Sumps, Concrete Pads, and Buildings. Details can be seen in Drawing 12 in appendix L.

Materials	$14,444/bldg
Labor	352/bldg
Total cost	$14,796/bldg
Total cost for buildings 2 and 3	$ 29,592

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE pipe:				
	4"	1.92/ft	10	19
	8"	6.02/ft	30	181
	10"	9.05/ft	10	91
Pump sump				
Base		339.00/ea	1	339
Intake structure		56.00/ft	8	448
Concrete		72.00/yd^3	9.4	676
Rebar		0.12/ft^2	760	91
Prefab building		30.00/ft^2	420	12,600
Total materials				14,444
Labor (apprentice)		176.00/day	2	352
Total labor				352

f. Buildings 2 and 3 Piping and Instruments. Details can be seen in Drawings 13 and 14 in appendix L.

Materials	$46,786/bldg
Labor	3520/bldg
Total cost	$50,306/bldg
Total cost for buildings 2 and 3	$ 100,612

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE pipe:				
	4"	1.92/ft	90	173
	6"	3.70/ft	20	74
	8"	6.02/ft	240	1,445
	10"	9.05/ft	20	181
Adapters				
	4"	19.00/ea	6	114
	6"	30.00/ea	1	30
	8"	53.00/ea	6	318
Butterfly valves				
	4"	123.00/ea	11	1,353
	8"	365.00/ea	24	8,760
	10"	473.00/ea	2	946
Flanges-sets (w/bolts)				
	4"	58.00/ea	11	638
	6"	88.00/ea	2	176
	8"	156.00/ea	24	3,744
	10"	244.00/ea	2	488
Miscellaneous				
Sample port - ½" (complete)		15.00/ea	2	30
TC port ¼" (complete)		15.00/ea	1	15
Pressure gauge (complete)		68.00/ea	2	136
EC meter/probe		501.00/ea	2	1,002
Flow meter/probe		1014.00/ea	2	2,028
Pump - 40 Hp		10,624.00/ea	2	21,248
Pump control panel		1900.00/ea	2	3,800
TC with display		87.00/ea	1	87
Total materials				46,786
Labor (apprentice)		176.00/day	20	3,520
Total labor				3520
Total cost				50,306

g. Buildings 2 and 3 – Electrical.

Materials	$33,612/bldg
Labor	1,248/bldg
Trenching berm	1,000/bldg
Total cost	$35,860/bldg
Cost for buildings 2 and 3	$ 71,720

Materials – Electrical

Note: For one building – trenching and wire runs averaged.	Unit cost, $	Units required	Extended cost, $
Electrical			
30-ft light poles installed	135.00/ea	8	1,080
High-voltage pwr ser. wire	15.59/ft	650	410,132
1 ea.-50-KVA 460-VAC service 15-KVA transformer to 240-VAC, and 110-VAC lights and Recept.	22,400.00/ea.	1	22,400
Total electrical materials			33,612
Electrical labor			
Apprentice	176.00/day	3	528
Journeyman	240.00/day	3	720
Total electrical labor			1,248
Trenching for wire installation			
Trenching – berm	2.50/ft	400	1,000
Total trenching cost			1,000
Total electrical cost			35,860

h. TW Line. Details can be seen in Drawing 15 in appendix L.

Materials	$3,010
Labor	352
Heavy equipment	876
Total cost	$4,238

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE pipe:				
	8"	6.02/ft	500	3,010
Total materials				3,010
Heavy equipment:				
Trac hoe		146.00/hr	6	876
Total heavy equipment				876
Labor (apprentice)		176.00/day	2	352
Total labor				352

i. Polishing Plant Feed Line. Details can be seen in Drawing 16 in appendix L.

Materials	$5,719
Labor	2,336
Heavy equipment	704
Total cost	$87,59

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE pipe:				
	8"	6.02/ft	950	5,719
Total materials				5,719
Heavy equipment				
Trac hoe		146.00/hr	16	2,336
Total heavy equipment				2,336
Labor apprentice		176.00/day	4	704
Total labor				704

j. Building 4 Sump, Inlet, Discharges, Pad, and Building. Details can be seen in Drawing 17 in appendix L.

Materials	$ 8,670
Labor	352
Heavy equipment	1,168
Total cost	$10,190

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE Pipe:				
	8"	6.02/ft	80	482
	12"	13.03/ft	60	782
Pump sump				
Base		339.00/ea	1	339
Intake structure		56.00/ft	14	784
Concrete		72.00/ft	4.9	356
Rebar		0.12.ft	400	48
Prefab building		30.00/ft^2	196	5,880
Total materials				8,670
Heavy equipment				
Trac hoe		146.00/hr	8	1,168
Total heavy equipment				1,168
Labor (apprentice)		176.00/day	2	352
Total labor				352

k. Building 4 – Piping and Instruments. Details can be seen in Drawing 18 in appendix L.

Materials	$24,415
Labor	704
Total cost	$25,119

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE Pipe:				
	6"	3.70/ft	10	37
	8"	6.02/ft	100	602
Adapters				
	6"	30.00/ea	1	30
Butterfly valves				
	8"	365.00/ea	13	4,745
Flanges–sets (w/bolts), $/set				
	6"	88.00/ea	1	88
	8"	156.00/ea	13	2,028
Miscellaneous				
Sample port - ½" (complete)		15.00/ea	3	45
TC port ¼" (complete)		15.00/ea	2	30
Pressure gauge (complete)		68.00/ea	1	68
EC meter/probe		501.00/ea	2	1,002
Flowmeter/probe		1,014.00/ea	3	3,042
Pump – 40 hp		10,624.00/ea	1	10,624
TC with display		87.00/ea	2	174
Total materials				24,415
Labor (apprentice)		176.00/day	4	704
Total labor				704
Total cost				25,119

l. Building 4 – Electrical.

Materials	$25,723
Labor	832
Trenching berm	425
Total cost	$26,980

	Materials – Electrical		
	Unit cost , $	Units required	Extended cost, $
Electrical			
30-ft light poles installed	135.00/ea	1	135
High-voltage pwr ser. wire	15.59/ft	1000	15,588
1 ea.–50-KVA 460-VAC service, 15-KVA transformer to 240-VAC, and 110-VAC lights and recept.	10,000/ea	1	10,000
Total electrical materials			25,723
Electrical labor			
Apprentice	176.00/day	2	352
Journeyman	240.00/day	2	480
Total electrical labor			832
Trenching for wire installation			
Trenching – berm	2.50/ft	170	425
Total trenching cost			425
Total electrical cost			26,980

m. Brine System. Details can be seen in Drawing 19 in appendix L.

Materials	$3,612
Labor	352
Heavy equipment	1,168
Total cost	$5,132

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE Pipe:				
	8"	6.02/ft	600	3,612
Total materials				3,612
Heavy equipment				
Trac hoe		146.00/hr	8	1,168
Total heavy equipment				1,168
Labor (apprentice)		176.00/day	2	352
Total labor				352

n. Building 5 Sump, Inlet, Discharge, Pad, and Building. Details can be seen in drawing 20 in appendix L.

Materials	$ 9,015
Labor	352
Heavy equipment	1,168
Total cost	$10,535

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE pipe:				
	8"	6.02/ft	65	391
	12"	13.03/ft	50	652
Pump sump				
Base		339.00/ea.	1	339
Intake structure		56.00/ft	12	672
Concrete		72.00/yd^3	4.9	356
Rebar		0.12/ft^2		
Prefab building		30.00/ft^2	196	5,880
Total materials				9,015
Heavy equipment				
Trac hoe		146.00/hr	8	1,168
Total heavy equipment				1,168
Labor (apprentice)		176.00/day	2	352
Total labor				352

o. Building 5 Piping and Instruments. Details can be seen in Drawing 21 in appendix L.

Materials	$21,080
Labor	704
Total cost	$21,784

	Materials – Piping and Instruments			
	Dia.	Unit cost, $	Units required	Extended cost, $
HDPE pipe:				
	6"	3.70/ft	10	37
	8"	6.02/ft	80	482
Adapters				
	6"	30.00/ea	1	30
Butterfly valves				
	8"	365.00/ea	9	3,285
Flanges–sets (w/bolts)				
	6"	88.00/ea	1	88
	8"	156.00/ea	9	1,404
Miscellaneous				
Sample port - ½" (complete)		15.00/ea	2	30
TC port ¼" (complete)		15.00/ea	1	15
Pressure gauge (complete)		68.00/ea	1	68
EC meter/probe		501.00/ea	2	1,002
Flowmeter/probe		1,014.00/ea	2	2,028
Pump – 40 hp		10,624.00/ea	1	10,624
Pump control panel		1900.00/ea	1	1,900
TC with display		87.00/ea	1	87
Total materials				21,080
Labor (apprentice)		176.00/day	4	704
Total labor				704
Total cost				21,784

p. Building 5 Electrical.

Materials	$16,391
Labor	1248
Heavy equipment	856
Total cost	$18,495

	Materials – Electrical		
	Unit cost, $	Units required	Extended cost, $
Electrical			
High-voltage pwr ser. wire	15.59/ft	410	6,391
1 ea.–50-KVA 460-VAC service, 15-KVA transformer to 240-VAC, and 110-VAC lights and recept.	10,000.00/ea		10,000
Total electrical materials			16,391
Electrical labor			
Apprentice	176.00/day	3	528
Journeyman	240.00/day	3	720
Total electrical labor			1,248
Trenching for wire installation			
Trenching – high voltage	1.25/ft	135	169
Trenching – backhoe	2.00/ft		0
Trenching – berm	2.50/ft	275	688
Total trenching cost			856
Total electrical cost			18,495

FT Plant and Controls		
a. Freezing pads, TW storage pond, and brine storage pond		
Freezing ponds	$479,607	
TW storage pond	620,327	
Brine storage pond	155,135	$1,255,069
Berm construction		141,692
b. Freezing pad spray system		42,236
c. Freezing pad outlet		65,659
d. Commercial plant/demonstration plant connection		2,576
e. Buildings 2 and 3 Inlets, discharges, pump sumps, Concrete pads, and buildings		29,592
f. Buildings 2 and 3 piping and instruments		100,612
g. Building 2 and 3 electrical		71,720
h. TW line		4,238
i. Polishing plant feed line		8,759
j. Building 4 sump, inlet, discharges, pad, and building		10,190
k. Building 4 piping and instruments		25,119
l. Building 4 electrical		26,980
m. Brine system		5,132
n. Building 5 sump, inlet, discharge, pad, and building		10,535
o. Building 5 piping and instruments		21,784
p. Building 5 electrical		18,495
Total Cost		$1,840,388

Product Water Treatment

Details can be seen in appendix M.

Plant cost	$380,000
Materials	10,000
Installation labor	6,240
Total cost	$396,240

Data:	
Material	Estimate
Labor	30 worker-days
Apprentice	$176/day
Journeyman	$240/day

Treatment of Product Water By-Products

No additional equipment required.

Product Water Transfer Pumping, Storage, and High-Service Pumping

Cannot estimate.

Concentrate Treatment

No additional equipment required.

Treatment of Concentrate By-Products

None required.

Concentrate Discharge

None.

Buildings

Building	$58,000
Septic system/ leach field	13,000
Electrical	15,000
Labor	2,080
Total cost	$88,080

Data:	
Building	Vendor quote
Septic system/leach field	Vendor quote
Electrical	75-KVA, 460-V 3 phase, 75-KVA, 460-V 3-phase to 240-V 1-phase transformer, load centers, 110-VAC lights and receptacles.

Land Site Development Costs

Details can be seen in Drawings 1 and 5 in appendix L.

Fence	$25,540
Electrical service	14,000
Trenching – high voltage	1,585
Labor	1,776
Final cost	$42,901

Data:	
Fence	6170 ft x 6 ft high
Fence Cost	$4.10/ft
16-ft Gate	$120 ea
Labor (Journeyman)	3 worker-days
Labor (Journeyman)	$240/worker-day
Labor (Apprentice)	6 worker-days
Labor (Apprentice)	$176/worker-day
Trenching – High Voltage	1268 ft
Trenching – High Voltage	$1.25/ft
Electrical Service	400 KVA, 460 V 3 phase

Permitting and Engineering

Cost = $90,000

In summary, the installed capital cost for the facility is as follows:

Feedwater delivery, collection, and transmission	$ 74,874
Raw water pretreatment	0
FT plant and controls	1,840,388
Product water treatment	396,240
Treatment of product water by-products	0
Product water transfer pumping, storage, and high-service pumping	0
Concentrate treatment	0
Treatment of concentrate by products	0
Concentrate discharge	0
Buildings	88,080
Land site development costs	42,901
Permitting and engineering	90,000
Total Installed capital cost	$2,532,483

ANNUAL OPERATING EXPENSES

Annual operating expenses for the base case are salaries, utilities (propane and electricity), solids disposal, maintenance, and bond payment.

Salaries

Salaries are estimated as follows:

Month	Workers Required/Shift	# of Employees	Loaded Rate	Cost/Month
January	2	9	17.6	$ 26,189
February	2	9	17.6	23,654
March	1	4	17.6	13,094
April	1	4	17.6	12,672
May	1	4	17.6	13,094
June	1	4	17.6	12,672
July	1	4	17.6	13,094
August	1	4	17.6	13,094
November	1	4	17.6	12,672
December	2	9	17.6	26,189
			Total	$166,424/yr

It should be noted that labor cost may be reduced during April through August when the plant is not fully operational, but this is not considered here.

Utilities

Utilities considered are propane and electricity.

Propane

Propane is used to heat the building housing the office and polishing plant.

Heater	200,000 Btu/hr @ 80 percent efficient
Propane Usage	2.76 gal/operating hr
Propane Cost	$0.69/gal.
Propane Cost/hr	$1.90

Month	Operating Days	Cost per month
January	20	$1,178
February	18	1,064
March	12	684
April	8	456
May	6	353
June	–	–
July	–	–
August	–	–
November	12	684
December	20	1,178
	Total	$5,597

Electricity Usage

Pumps (40 hp)	29.8 kW
Power cost	$0.04/kWh
Pump operating cost	$1.19/hr

Pump operation (commercial facility)	
P1	55 days during November–March
P1 operating cost	$1571/yr
P2 and P3	Continuous November–August
P2 operating cost	$8707/yr
P3 operating cost	$8707/yr
P4	Continuous March 15–May 31
P4 operating cost	$2,205/yr
P5	Continuous June 1–June 30
P5 operating cost	$859/yr

Pump operating (demonstration plant)	
Pumps 7.5 hp	5.6 kW
Pump operating cost	$0.22/hr
P1, P2, P3	Operate continuously June–August
P1 operating cost	$501/yr
P2 operating cost	$501/yr
P3 operating cost	$501/yr

The total electric cost for pump operation = $23,555/yr

Electric heaters are operating in Building 1, 2, 3, and 4, and Demo Sheds 1, 2, and 3.

All heaters are 3 kW. The operating cost = $0.12/hr.

Applying the same operating schedule as used in the propane heater yields:

Hours Operating/Year	3,744 hr/yr
Cost per Heater	$449/yr
Cost for All Heaters	$3,145/yr

Lights and 110-VAC circuits are assumed to draw 30 kW continuously.

Cost for 110 VAC	$8,755/yr
Total Electric Cost	$35,455/yr
Total Utility Cost	$41,052/yr

Solids Disposal

If an economically beneficial use for the salts in the brine cannot be found, costs for salt disposal will become an issue of importance in a commercial-scale FT plant. Based on the following assumptions, an estimated cost for salt disposal in the City of Devils Lake Municipal Landfill would be approximately $3370 per freezing season.

Assumptions

Salt Production: 392,600 lb
Precipitate Production: 169,000 lb
Salt Mass: 2700 lb/yd^3 of solid waste
Trucking: $4/yd^3
Disposal: $6/yd^3

Solid Waste Production

392,600	Pounds of salt produced from brine
+ 169,000	Pounds of precipitate
561,600	Pounds of solid waste produced
÷ 2,000	Pounds of solid waste per yd^3 yard
281	Total yd^3 of solid waste produced

Disposal Cost

$ 6	Per yd^3 for trucking
6	Per yd^3 for disposal
$ 12	Total cost/yd^3
x 281	Total yd^3 of solid waste produced
$3,372	Total cost for disposal of solid waste produced

Maintenance Cost

Maintenance costs are estimated to be 1 percent of installed capital costs.
Maintenance costs = $25,325/yr.

Bond Interest

The plant is assumed to be 100 percent financed by municipal bonds with a 20-year life. The bond interest rate is assumed to be 6 percent APR. The annual loan payment in monthly installments = $220,782/yr.

	Annual Cost
Salaries	$166,424
Utilities	41,052
Solids Disposal	3,372
Maintenance Cost	25,325
Bond Interest	220,782
Total	$456,955

The estimated cost of TW produced by a 93.45 Mgal/yr FT plant is $4.89 per 1000 gal.

APPENDIX L

POLISHING PLANT LITERATURE

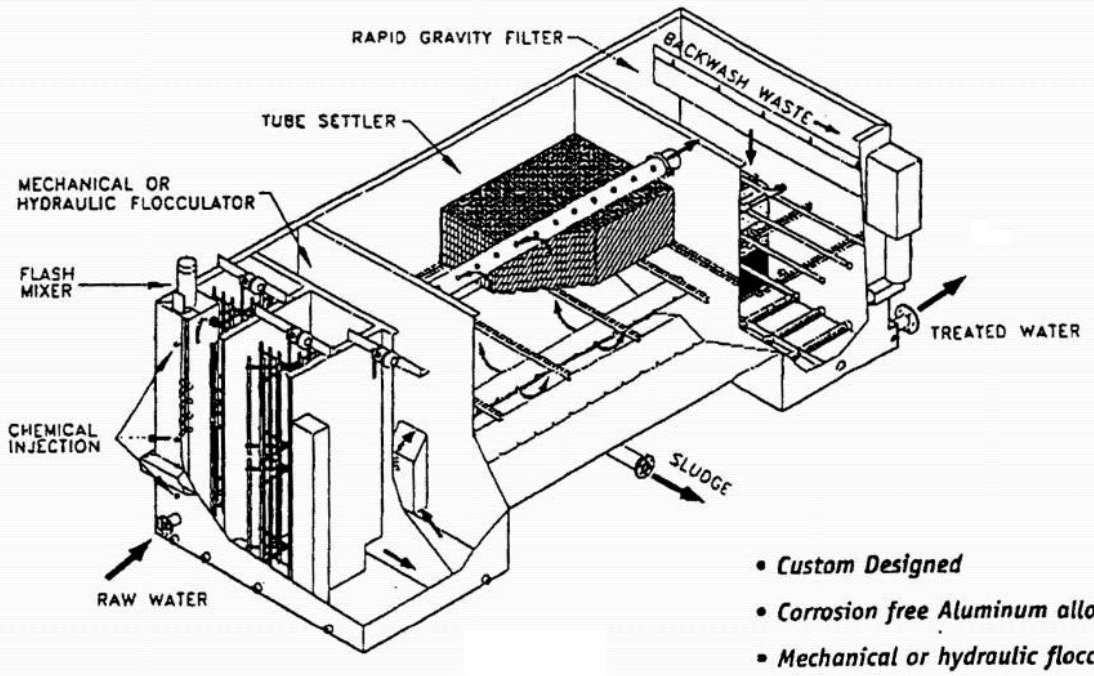
$360 375,000 1-TANK - 2ND TRAIN 50% COST OF 1ST SYSTEM
DOES NOT INCLUDE BLDG CONTROLS, ETC.

"ST" Water Treatment Plant

Flocculation/Upflow Clarification/Filtration

n. Clearwater

The ST range of water treatment plants use proven technologies to produce clear, safe drinking water from low quality sources. Capable of purifying the most difficult types of raw water, they are particularly suitable for surface waters with high and variable contaminant loadings. They excel in treating cold water with high levels of turbidity, iron and manganese.



- *Custom Designed*
- *Corrosion free Aluminum alloy*
- *Mechanical or hydraulic flocculation*

How it Works

A coagulant is added to the raw water to precipitate dissolved contaminants and encourage suspended particles to group together in the form of "floccs". Gentle agitation in the flocculation zone encourages the floccs to grow and they are then removed by settling within a clarification zone. The accumulated solids are removed hydraulically from the clarifier floor and the clarified water passes on to the filter for final polishing. Solids accumulating within the filter are periodically removed by automatically controlled water or air/water backwashing.

Advantages and Key Features

- Capacities to 700 USgpm, 3,800 m³/d per module: multiple units are available.
- Excellent water quality to less than 0.1 NTU.
- 2.5 log, multi-barrier protection against Giardia and Cryptosporidium.
- All processes custom sized to best meet water quality goals and regulations.
- Quiet, simple and easy to operate with minimal operator intervention.
- Pre-assembled and pre-tested packaged plant often saving 50% or more over in-situ construction.
- Only water, waste and electrical connections needed prior to start up.
- Automatic controls and monitoring systems customized to meet local needs.
- Inlet flow set at constant rate for simple operation, filter rate modulated to match inlet flow.
- Supplied complete with chemical dosing and water quality monitoring systems.

people

technology

solutions

people

technology

solutions

Typical Plant Dimensions

(Each plant is custom sized to meet the needs of each application)

Capacity USgpm	20 mins. flocculation 30 mins. settling time Filter rate 3.6 USgpm/ft²			20 mins. flocculation 60 mins. settling time Filter rate 3.6 USgpm/ft²			30 mins. flocculation 90 mins. settling time Filter rate 3.6 USgpm/ft²		
	W	H	L	W	H	L	W	H	L
50	7'6"	7'9"	25'4"	7'6"	7'9"	23'3"	7'6"	9'6"	30'6"
100	8'0"	7'9"	31'6"	8'0"	9'6"	29'9"	8'0"	9'6"	29'3"
150	8'0"	7'9"	25'4"	7'6"	9'6"	38'6"	8'0"	9'6"	43'6"
200	13'6"	7'9"	33'9"	10'0"	9'6"	38'6"	10'6"	9'6"	45'6"
300	8'0"	9'6"	31'6"	8'0"	9'6"	44'9"	8'0"	9'6"	57'3"
400	20'0"	9'6"	44'0"	12'0"	9'6"	44'9"			
500	12'0"	9'6"	36'0"						
600	12'0"	9'6"	43'6"						

Flash Mixing
- Multi chemical injection ports for coagulant, polymer, pH adjustment, etc.
- Static or powered mixers.

Flocculation
- Multi stage hydraulic or mechanical flocculation.
- Carefully designed to minimize short circuiting.
- Hydraulic flocculation has variable nozzles for site adjustable energy input.
- Mechanical flocculators fitted with variable speed drives.

Clarification
- Inlet/outlet manifolds for even flow distribution.
- 60°, rigid plastic, settling tube modules, UV and chemical resistant.
- "V" hopper bottom for sludge thickening and hydraulic sludge removal.
- Sludge blanket sample and location ports.
- Flat bottom, mechanical sludge removal option available.

Filtration
- Mono, dual and multi media options.
- Water backwash with surface wash.
- Air scour option available for reduced wastage and improved cleaning.
- Gravel support base with pipe lateral underdrain.
- "Non-gravel" underdrain systems available.

Chemical Systems
- Full range of chemical mixing and dosing systems.
- Solution tanks, mixers, dosing pumps and safety equipment.

Control Systems
- PLC based for fully automatic operation and backwash initiation and sequencing.
- SCADA system with data logging, report generation and remote monitoring/operation features available.

Water Quality Monitoring
- Analytical packages ranging from bench top testers to full on-line instrumentation are available.

Tank Construction
- Aluminum 5086-H116 and 6061, built to American Aluminum Association/CSA W47.2-M1987. Smooth, attractive, maintenance free surface. Steel and stainless steel are available.

Pacific Keystone Technologies Inc.
Engineering and Manufacturing of Water and Wastewater Purification Systems
PO Box 360, Black Diamond, Washington 98010-0491

Tel (360) 886-1596 • Fax (360) 886-2480
E-mail: keystone@clearwaterworld.com
Website: www.clearwaterworld.com

PacificKeystone
Technologies Incorporated

The Clearwater Group™

APPENDIX M

LANDOWNER RECLAMATION APPROVAL LETTER

WANZEK

HEAVY/INDUSTRIAL CONSTRUCTORS & CRANE SERVICE

Wanzek Construction, Inc.
UPS/Fed Ex: 16553 37R St SE
Fargo, ND 58103
Mail: PO Box 2019
Fargo, North Dakota 58107
Physical: Exit 342 on I-94
701/282-6171
701/282-6166 FAX
e-mail: info@wanzek.com

January 21, 2002

Bradley G. Stevens
Energy & Environmental Research Cneter
University of North Dakota
P.O. Box 9018
Grand Forks, ND 58202-9018

Dear Mr. Stevens:

We have completed the Reclamation of Wanzek Construction, Inc. property in Devils Lake to their satisfaction per your purchase order # 402218. Please expedite payment of our invoice # 7675 dated 12/17/01.

Thank you.

Leo Wanzek
President