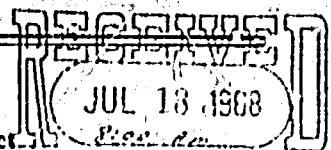


1604.3

1. Considered 9-24, 1968
2. Name of Applicant CITY OF MADISON
3. Post Office Address _____
4. Amount of water claimed 1.35
5. Source of water supply GROUND WATER
6. Water to be used for MUNICIPAL
- Acres to be irrigated _____
7. Water to be diverted and used in LAKE county
about IN CITY LIMITS miles of _____
8. Proof of Publication Received 1st
Not Received _____
9. Application Approved _____
Subject to _____
Not Approved _____
Action deferred _____
10. Remarks:

No. 1604-3Water Division No. 3BIG SIOUX RIVERDistrict 1

(Blanks to be Filled by the Engineer for the W. R. C.)

STATE WATER RESOURCES COMM.
PIERRE, SOUTH DAKOTA

APPLICATION FOR PERMIT To Appropriate Water within the State of South Dakota

(NOTE—Draw a line through items not applicable.)

1. Name of applicant City of Madison
 Postoffice address P.O. Box 111, County Lake, State South Dakota

I. If a corporation Municipal Corporation

- (a) Name of same City of Madison
 (b) Date and place of incorporation _____
 (c) Amount of capital stock _____
 (d) Amount paid in _____
 (e) Names and addresses of directors Mayor and four Commissioners

(NOTE—A certified copy of articles of incorporation must accompany the application.)

II. Method of accomplishing the work and financial resources of the applicant:

- (a) Method of accomplishing work (Whether by contract, employment of others, or by direct labor) _____
 (b) Cash on hand, \$ _____ (c) Treasury stock, \$ _____
 (d) Bonds to be issued, \$ _____ (e) Other resources, \$ 35,000.00

2. Name of diversion work City Wells #10 & #11
 3. Amount of water claimed 1.35 cubic feet per second 600 GPM
 4. Source of water supply Ground Water
 5. Location of point of diversion Approximately 350' S.W. of the center of Sec. 8,
T106N R52W on _____ bank Lake County.
 6. Annual period or periods during which water is to be used January 1 through December 31
 7. To be used for:

I. Irrigation or domestic use: Gravity, overhead sprinkling or combination system? _____

- (a) Number of acres to be irrigated _____ acres.

- (b) Legal subdivisions to be irrigated _____

(NOTE—A list of lands to be irrigated, giving each subdivision and fraction with acreage thereof, should be written here, or may be appended as a part of this application. Same must also be shown on accompanying map.)

- (c) Statement as to domestic use (giving location, etc.) _____

II. Stockwatering, mining, milling, power, fish culture, fire protection and public recreation:

- (a) Nature of use
- Municipal purposes for City of Madison
-
- Name any of the above uses claimed

- (b) Amount of power to be generated _____ horse power.

Amount claimed for engine cooling: _____

- (c) Location of plant _____

- (d) Method of developing power _____

- (e) Point where water will be returned to stream: _____

SEE MAP NO. 556-3

8. Estimated cost of work:

(a) Head Gates, \$-----
 (c) Fluming, \$----- (d) Canal-earth, \$-----
 (e) Other structures ----- \$-----
 (b) Pumping plant, \$-----
 Rock, \$-----
 Total, \$-----

9. Description of diversion works:

I. Nature of works: (Reservoir, dam, ditch, flume, pumping plant, etc.)

II. Dimensions of works.

(a) Dam: Height ----- feet; length at bottom ----- feet; length at top ----- feet; thickness at bottom ----- feet; thickness at top ----- feet; slope at front water face -----; slope at back face -----
 material used in construction -----

(b) Reservoir: Capacity when filled ----- acre feet. Surface area at highwater mark ----- acres.

DEPTH AT OUTLET-Feet	SURFACE AREA AT EACH DEPTH AT OUTLET--ACRES	FEET	ACRE-Feet CAPACITY

(c) Head gate: Width ----- feet; height ----- feet;
 Material -----

(d) Canal: Total length ----- miles.

LOCATION BELOW HEADGATE	DEPTH	BOTTOM WIDTH	WIDTH AT WATER-LINE	GRADE PER MILE
At ----- Mile	----- feet	----- feet	----- feet	----- feet
At ----- Mile	----- feet	----- feet	----- feet	----- feet
At ----- Mile	----- feet	----- feet	----- feet	----- feet
At ----- Mile	----- feet	----- feet	----- feet	----- feet
At ----- Mile	----- feet	----- feet	----- feet	----- feet
At ----- Mile	----- feet	----- feet	----- feet	----- feet

(Give dimensions where reductions in size are made.)

10. Time required for completion of work ----- One ----- year.

11. Time required for complete application of water to the proposed beneficial use ----- One ----- years.

12. Choice of newspaper for publication of notice of intention to appropriate -----
 Madison Daily Leader, Madison, South Dakota

STATE OF SOUTH DAKOTA

County of ----- ss.

I, -----, being first duly sworn
 on my oath depose and say: That my relation to the above described undertaking is that of owner; that I have
 read the above foregoing statement, examined the map accompanying the same, and that I know of my own
 personal knowledge that the matters therein stated and shown are true.

Signed -----

Subscribed and sworn to before me this ----- day of ----- 19-----

Notary Public (or other qualified officer.)

*Each diversion must have a headgate or measuring device.

Remarks by State Water Resources Commission:

THIS PERMIT PROPOSED DEVELOPMENT OF 1.35 C.F.S. OF WATERS WITH DRAWN FOR FUTURE USE BY THE CITY OF MARION UNDER PERMIT 747-3. A TOTAL OF 5.71 CFS. REMAINS UNDER 747-3.

STATE OF SOUTH DAKOTA
County of HUGHES } ss.

Pierre, South Dakota, OCTOBER 1, 1968

This is to certify that the foregoing application was received by the Commission at 8:00 o'clock PM upon the 18TH day of JULY, 1968.

State Water Resources Commission

By:

Durston Lane
for Chief Engineer, Executive Officer

Number of permit 1604-3

Date of first receipt of application JULY 18, 1968

Date of return to applicant for correction, amendments or changes required as follows: AUGUST 1, 1968

Date of receipt of corrected application AUGUST 16, 1968

Date from which applicant may claim right NOVEMBER 10, 1960

Approved SEPTEMBER 24, 1968, Recorded in Book 10 Page 265

This is to certify that we have examined the foregoing application for a permit to appropriate water of the State of South Dakota, and we hereby grant the same as stated herein, subject, however, to the following limitations and conditions:

1st. The equivalent of at least one-fifth of the work above specified is to be completed on or before

MARCH 24, 1969

2nd. The whole of said work is to be completed on or before SEPTEMBER 24, 1969

3rd. The limit of time for proof of beneficial use of water appropriated in accordance herewith is

SEPTEMBER 24, 1970

4th. The water appropriated shall be used for the purpose of MUNICIPAL USE

5th. The prior right of all persons who, by compliance with the laws of the State of South Dakota, have acquired a right to the use of water, must not be injuriously affected by this appropriation.

6th. The amount of the appropriation herein granted shall not exceed 1.35 cubic feet per second, neither shall it exceed the capacity of the above described system of diversion works, nor the least amount of water that experience may hereafter indicate as necessary for the production of crops by the exercise of the best husbandry; and further, said appropriation must be limited to not more than one twentieth (1/20) of one cubic foot of water per second of time for each acre of land to which water is actually

USED FOR MUNICIPAL PURPOSES

and beneficially applied for irrigation on or before SEPTEMBER 24, 1970; said water to be used during the following described annual period:

Witness my hand this 1ST day of CONTINUOUSLY OCTOBER, 1968

State Water Resources Commission

By:

XXXXXX
Chief Engineer, Executive Officer

Certificate of Construction Issued APRIL 29, 1970

Water License Issued APRIL 29, 1970

#10

9. (Continued)

III. Well Specifications

(a) Hole and casing 20'' dia Depth 260'

Size of drill hole or excavation 20'' Depth 260'

Type of casing Steel
(wood, concrete, steel, etc.)

Size of casing 20 inches dia, Thickness of casing 78.60 lb/ft

Length of casing 230 If collection gallery, length, size and depth of gallery

(b) Screens

Type of perforated screen Large opening, #304 S. S. Shutter type

Size of perforated screen 12'' 30'
(diameter) (length)

Thickness of gravel pack 32'' dia, length of gravel pack 30'

(c) Water Bearing Materials

Distance to water 230' Character of water bearing materials Fine sand

Thickness of water bearing material 37'

(d) Pump and Motor

Type of pump Turbine
(centrifugal, propeller, mixed flow, etc.)

Name of pump, size 8''

Kind of motor Electric
(gasoline, electric, diesel, etc.)

Horsepower 60, Name of Motor

(e) Complete well

Capacity 600 gpm at drawdown of 10' Estimated cost 30,000.00

(f) Owner of land upon which well is located City of Madison, Name

P. O. Box 111 Madison, South Dakota 57042
Address

(g) Distance to nearest existing wells

On same owner's property rods On property owned by others rods

None known within 1 mile at this depth.

9 (Continued)

III. Well Specifications

(a) Hole and casing

Size of drill hole or excavation 14 in. dia., Depth 260 ft.Type of casing Steel
(wood, concrete, steel, etc.)Size of casing 10 in. dia., Thickness of casing 0.5 in.Length of casing 230 ft. If collection gallery, length, size and depth of gallery _____

(b) Screens

Type of perforated screen Wire wound-#304 S.S. Johnson - 0.030 slotSize of perforated screen 30 feet of 8 - in. screen.
(diameter) (length)Thickness of gravel pack 24 in. dia., length of gravel pack 20 feet

(c) Water Bearing Materials

Distance to water 30 Character of water bearing materials clean firm fine sand. Cumulative % retained on sieve openings: 0.066 - 4; 0.047-8; 0.038-18; 0.023-37; 0.016-74; 0.012-88; 0.008-96%.Thickness of water bearing material 30 feet

(d) Pump and Motor

Type of pump Submersible turbine.
(centrifugal, propeller, mixed flow, etc.)Name of pump Jacuzzi, size 6"Kind of motor 440 v - 3 ph - 3600 rpm
(gasoline, electric, diesel, etc.)Horsepower 25, Name of Motor Franklin

(e) Complete well

Capacity 200 gpm at drawdown of 30, Estimated cost \$30,000.00(f) Owner of land upon which well is located City of Madison
NameMadison, South Dakota
Address

(g) Distance to nearest existing wells

On same owner's property _____ rods. On property owned by others _____ rods

None known within 1 mile of this well

WATER LICENSE NO. 1604-3

(1) WHEREAS, On the 18th day of July A. D. 1968
the City of Madison

made Water Right Application No. 1604-3 for a permit to use 1.25 cubic feet per second of the water
of ground water
County of Lake State of South Dakota, for municipal

purposes; and

(2) WHEREAS, On the 1st day of October A. D. 1968
Permit No. 1604-3, with a date of priority of November 10, 1960

was issued to said applicant for the diversion of said water, and provided for the completion of construction of the water
supply system therein described on or before the 24th day of September A. D. 1968 and for the
application to beneficial use of said water on or before the 24th day of September A. D. 1970

and:

(3) WHEREAS, It is hereby certified that the applicant has complied with the provisions of the laws of the State of South Dakota
relating to completion of the construction of the water supply system and is entitled to divert 1.22 cubic feet
per second of water for beneficial use and.

(4) WHEREAS, It is hereby certified that the applicant has complied with the provisions of the laws of the State of South Dakota
relating to the application of water to beneficial use of the following extent:

water is used for municipal purposes by the City of Madison

(5) NOW, THEREFORE By the virtue of the authority vested in us by the laws of the State of South Dakota, We hereby grant and confirm to the City of Madison

the holder and owner of said permit No. 1604-3 a water right, dating from November 10, 1960 to use of 1.24 cubic feet per second of the waters of ground water

in the County of Lake and State of South Dakota, or so much thereof as may be necessary for the purposes hereinbelow mentioned, to be diverted at Point #1, 300 ft. south and 175 ft. west and point No. 2, 600 ft. south and 500 ft. west of the Center of Section 8, T106N, R52W

~~and conducted through the City water distribution system~~

for the purpose of municipal use

Subject to any limitations listed in Water Right Permit No. 1604-2 and subject to the laws of the State of South Dakota.

WITNESS, My hand and seal of our office at Pierre, South Dakota
this 29th day of April A. D.
Nineteen Hundred and Seventy

WATER RESOURCES COMMISSION

B.:

Chief Engineer, Executive Officer, J.W. GRIMES

Form 15.

Permit No. 1604-3

Water Diversion No. 3 Big Sioux River Water District

CERTIFICATE OF CONSTRUCTION

This is to Certify, That the City of Madison

the holder of
Permit No. 1604-3, issued upon Application No. 1604-3, bearing date of priority of November 10,
1960 authorizing the diversion of 1.35 cu. ft. per second of the waters of
ground water County of Lake, State of South Dakota at
points No. 1, 300 ft. south and 175 ft. west and Point No. 2, 600 ft. south
500 ft. west of the center of Section 8, T106N, R52W

for municipal

purposes, has a complied with the provisions of the laws of the State of South Dakota relating to proof of
completion of the works of diversion set out and described in said Permit; that said works are found in satisfactory
condition for diverting and conveying to the place of intended use 1.22 cu. ft. per second of water.

Date April 29, 1970

WATER RESOURCES COMMISSION

By:

J.W. GRIMES, Executive Officer

PROOF OF PUBLICATION

STATE OF SOUTH DAKOTA } ss.
County Lake

Grace M. Johnson being duly sworn, deposes and says the annexed printed copy of Notice of Intention to Appropriate Water was taken from the

Madison Daily Leader a newspaper which during the whole time of publication of said notice herein after stated, has been and is printed and published in the

TKW City of Madison County of Lake and State of South Dakota;

that the said notice was published in said newspaper on the following dates:

Tuesday, August 20, 1968
Tuesday, August 27, 1968

Tuesday, September 3, 1968
Tuesday, September 10, 1968

in each and every issue of the full number thereof, the first publication being made on the 20th day of August 1968 and the last publication on the 10th day of September 1968, upon which days or times of publication aforesaid the newspaper was regularly published, and that during the whole time of said publication he was Merrill D. Hunter the printer and publisher^X of the said newspaper.

Grace M. Johnson

Subscribed and sworn to before me this 10th day of September A. D. 1968

B. Lloyd C. Oelke
Notary Public Lake County, S. D.

STATE OF SOUTH DAKOTA
Aug. 20, 27, Sept. 3, 10, 1968
APPROPRIATION OF WATER
August 12, 1968
Notice is given that the City of Madison, S. Dakota, has made an application in accordance with the provisions of the water laws of South Dakota for a permit to appropriate for beneficial use 1.35 cubic feet of water per second of time from the ground water through the city wells No. 10 and 11, the point of diversion of which are to be located in the NE 1/4 of the SW 1/4 of Section 8, Twp. 106N, Range 52W. Said water to be used for the purpose of providing municipal supplies for the City of Madison.
This application will be taken up by the State Water Resources Commission at their office at Pierre for consideration upon the 24th day of September, 1968, at 2:00 P.M. All interested persons may appear and be heard.
Appropriate action will be taken by the Water Resources Commission after suitable time has elapsed for the consideration of any or all information presented.
State Water Resources Commission
BY: BURTON F. JONES
Water Rights Specialist

RECEIVED
SEP 16 1968

STATE WATER RESOURCES COMM.
PIERRE, SOUTH DAKOTA

APPROPRIATION OF WATER

Pierre, S. Dak., -----August 12-----, 1958.

and for _____

Appropriate action will be taken if the Water Resources Commission after suitable time has elapsed for the consideration of any or all information presented.

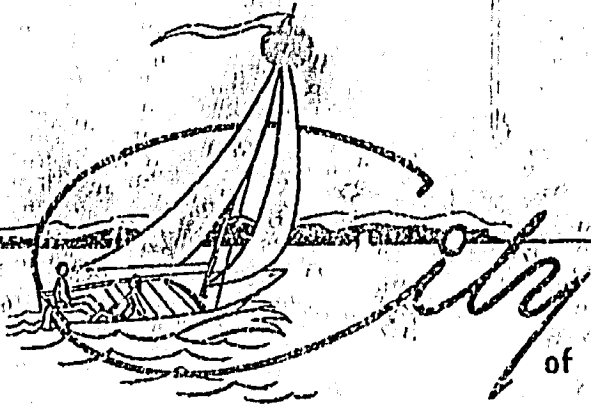
By:

~~Chief Engineer, Executive Officer~~

Burton F. Jones
Water Rights Specialist

P.O. BOX 111
MADISON, SOUTH DAKOTA 57042

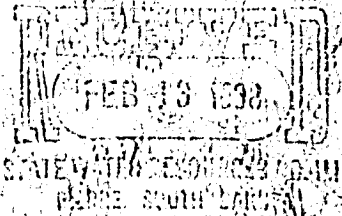
PHONE 256-4386



of MADISON, SOUTH DAKOTA

February 8, 1968

Burton F. Jones
Water Rights Specialist
South Dakota Water Resources Commission
State Office Building
Pierre, South Dakota 57501



Dear Mr. Jones:

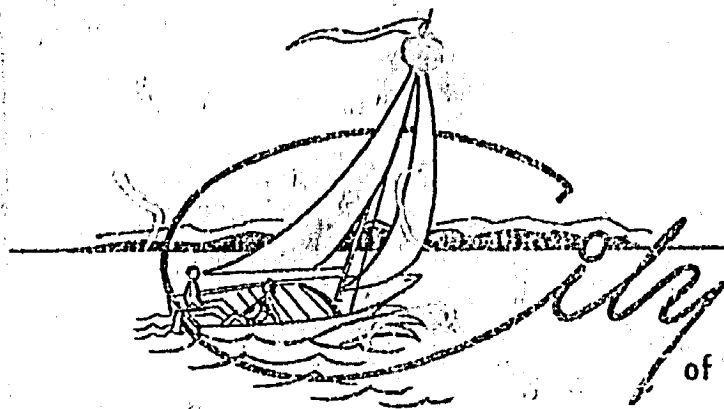
The City of Madison is interested in sinking a new well to a deeper vein than the present source provided for in water right No. 747-3. This site would be at the same location described in application No. 1453-3 but at the 230 foot depth rather than at 50 feet. Test borings at this point last fall indicated a potentially good supply at that depth. Our presently pumped shallow well field is being mined severely and the exploration for construction of, and piping water from another shallow well field to the treatment plant is not presently feasible from an economical as well as a time standpoint.

The question is whether or not our initial reservation of 11.11 cfs for City usage applies to a source at 260 feet or only to the shallow outwash area on the water right map 556-3. Enclosed is an application for permission to appropriate water from the deeper source. May I hear from you soon as to the Water Resources policy concerning water rights of overlying aquifer and their decision on this application.

Very truly yours,

Francis E. Brink

Francis E. Brink
Civil Engineer



P. O. BOX 111
MADISON, SOUTH DAKOTA 57042

PHONE 256-4586

of MADISON, SOUTH DAKOTA

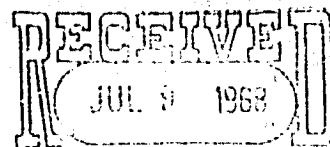
July 8, 1968

Francis E. Brink, City Engineer
City Hall
Madison, South Dakota 57042

Mr. Burton F. Jones
Water Rights Specialist
South Dakota Water Resources Commission
State Office Building
Pierre, South Dakota 57501

Dear Mr. Jones:

Re: Recent Well Construction, Madison, South Dakota.



STATE WATER RESOURCES COMM.
PIERRE, SOUTH DAKOTA

There seems to have been a mix-up in water appropriation permits for Madison during the past year of crash programming for additional water supplies. I will attempt to reconstruct the procedure from this end and perhaps you can get your file completed on our applications.

In October 1967 or about, Madison submitted an application for permission to appropriate water for municipal supplies, Permit No. 1453-3, relating to City Well #9. The location was 350' S. W. of center of Sec. 8-106-52, Lake County at the 50' depth. This was a large diameter shallow well, completed that fall and is presently pumping about 450 gpm.

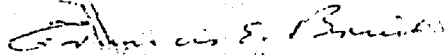
On February 8, 1968, I had written correspondence with your office concerning the legality of our going deeper for water and at that time an application for permission to do so was submitted. This was for Well #10, constructed at approximately the same location as Well #9 but to a depth of 260'. It was originally estimated that Well #10 would produce 600 gpm and the application included this amount. As construction proceeded, sand samples were analyzed and a more realistic figure for volume was established as 300 gpm at 75' drawdown. Therefore, two wells were constructed at this lower depth about 700' apart and a total pumping rate of 600 gpm was established for two wells, Well #10 and Well #11.

If you have followed the chronology above you can probably see that somewhere along the line there was a misunderstanding that we did not complete #9; at least that is what my correspondence and discussion with Mr. Driscoll would indicate. In reality, three wells were constructed and are now all pumping.

Perhaps it would be best for us to resubmit the application for #10 and #11 and you proceed with #9 as finished. If this is satisfactory with you, please send me several of Form 2 and Form 2A and I will get these back to you as soon as possible.

Sorry for the inconvenience and delay. Water is an elusive subject at best even without paper work. We want to cooperate on it though - we may need all the help we can get scmeday.

Very truly yours,



Francis E. Brink
City Engineer

Form 2

APPLICATION FOR PERMIT
TO APPROPRIATE WATER WITHIN THE STATE
OF SOUTH DAKOTA

1. CITY OF MADISON

P. O. Box 111

Madison

Lake

South Dakota

I MUNICIPAL CORPORATION

(a) City of Madison, South Dakota

(b)

(c)

(d)

(e) Mayor & Four Commissioners

II

(a)

(c)

(b)

(e) Other sources \$35,000.00

(d)

2. FUTURE SUPPLY

3. 600 gpm

1.35 cfs

4. Section 8-106N-R52W measured from the 5th PM

Lake County, South Dakota ~~GROUND WATER~~

5. Approximately 350' S. W. of the center of Sec. 8-106-52

Lake

6.

January 1 through December 31

7.

I

a

b City limits of City of Madison, Madison, South Dakota

~~c Future water supply for all Municipal purposes, City of
Madison, South Dakota~~

II

a All municipal purposes, Madison, South Dakota

8.

9.

10.

11.

12.

Madison Daily Leader, Madison South Dakota

Lake

1604.3

July 1, 1968

Mr. Francis E. Brink, Engineer
City of Madison
Madison, South Dakota 57042

Dear Mr. Brink:

Per your letter of July 8, we are enclosing Forms 2 and 2A
for your use.

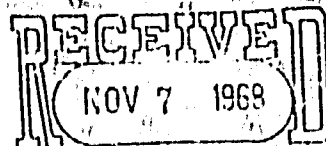
Wells #10 and #11 can both be included on one application.
If you wish, we can spot the wells on the map submitted
with your future use withdrawal, and it will not be necessary
for you to submit a new map.

Should you have further questions, feel free to contact this
office.

Sincerely,

BURTON F. JONES
Water Rights Specialist

Form 2 (6)
Form 2A (6)

Permit No. 1604-3Water Division No. 3 Big Sioux River Water DistrictSTATE WATER RESOURCES COMMISSION
PIERRE, SOUTH DAKOTA

Notice of Application of Water to Beneficial Use

(This blank must be filled out by holder of permit and forwarded to the State Water Resources Commission at least sixty days before the time set for application of water.)

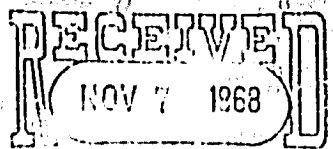
(P. O.) 111 Madison, South Dakota(Date) Nov. 6, 1968

TO THE STATE WATER RESOURCES COMMISSION OF SOUTH DAKOTA, PIERRE:

DEAR SIR: Notice is hereby given that on the 15th day of November
1968, at MADISON County of LINCOLN State of South Dakota,
 before _____ proof will be submitted of the application to beneficial use
 (Examining Engineer or Officer)
 of 1.35 cubic feet per second of the waters of Ground Water
 In accordance with the terms and conditions of Permit No. 1604-3
 heretofore issued by the Water Resources Commission of South Dakota.

- The name and postoffice address of the person or corporation holding said permit are CITY OF
MADISON, SOUTH DAKOTA P.O. 111
- The use to which said water has been applied is MUNICIPAL WATER SUPPLY
- The amount applied to beneficial use is 1.35 cfs
- The place where said water is used is (if for irrigation, give full and accurate description of the lands irrigated) CITY OF MADISON
- The name of the canal or ditch or other works by which said water is conducted to such place of use is _____
- The right to take the water from such works is based upon permit No. 1604-3
- The source of supply from which such water is diverted is GROUND WATER
- The date of priority which said user is prepared to establish is Nov. 10, 1960

(Signed) Francis C. Brand, P.E.
City Engineer
Madison, South Dakota

Permit No. 1664-3Water Division No. 3 BIG SIOUX RIVER Water District

NOTICE OF COMPLETION OF WORKS

STATE WATER RESOURCES COMM.
PIERRE, SOUTH DAKOTA

This blank must be filled out by the holder of permit and forwarded to the Executive Officer at least 60 days before the time set for completion of works

(P. O.) CITY OF MADISON, SOUTH DAKOTA P.O. 111(Date) Nov. 4, 1968

TO THE STATE WATER RESOURCES COMMISSION
OF SOUTH DAKOTA, PIERRE:

DEAR SIR: Notice is hereby given of the completion of the works for the diversion of 1.35
cu. ft. per second of the waters of the state from Ground Water
through the Municipal Water Treatment Plant
for Municipal Water Supply purposes

in accordance with the terms and conditions of a certain permit heretofore issued by the Water Resources Commission of the State of South Dakota.

1. The name of the person or corporation holding said permit is CITY OF MADISON, SOUTH DAKOTA
2. The postoffice address of such person or the place of business of such corporation is P.O. 111 Madison
County of LAKE State of SOUTH DAKOTA
3. The number of such permit is 1664-3 and the date set for the completion of such work is NOVEMBER 15, 1968
4. Said water to be used for MUNICIPAL WATER SUPPLY purposes.
5. Said works of diversion will be fully completed on the date set for such completion, and the amount of water which said works are capable of conducting to the place of intended use, in accordance with the plans accompanying the application for such permit, is 1.35 cubic feet per second.
6. The amount of land for which said water is available is _____ acres,
particularly described as follows: CITY OF MADISON

I hereby certify that the facts set forth in the above notice are true.

City of Madison

Attest: James R. Gregerson (Signature of Owners)
City Auditor

H. I. Kelly

Permit No. 1604-3

Water Division 3 SIOUX RIVER Water District

**REPORT OF EXAMINATION OF WORKS
AND/OR APPLICATION OF WATER TO BENEFICIAL USE**

TO: Water Resources Commission, State Office Building No. 2, Pierre, South Dakota 57501

I have this day made a thorough examination of the water use system constructed by the City of
Madison of Madison, South Dakota holder
of Permit No. 1604-3, bearing date of priority of November 10, 1960
authorizing the diversion of 1.35 cu. ft. per second of the waters of ground water
for municipal purposes, in Lake County.

I have to report on the condition of the same as follows:

The Water Use System consists of,

A. Works used to divert the water:

Well No. 10
257 ft. deep
8 inch casing, 8 inch setting
232' setting - 4" drop pipe

Well No. 11.
250 ft. deep
8 inch casing, 8 inch screen
218' setting - 4" drop pipe

B. Works used to transport water to place of use,

Six inch and smaller main distribution system

C. Works used to apply water to beneficial use.

Residential and commercial outlets

The system is in the following condition: very good
The point of diversion is located from center of Section 8, T106N, R52W, No. 10, 300 ft.
south, 175 ft. west. No. 11, 600 ft. south, 500 ft. west

The works are capable of diverting and conveying to the place of use 1.22
cu. ft. per second of water which is to be used for municipal purposes

Water has been put to beneficial use to the maximum extent as follows: the two wells were constructed
in 1968 and have been used for municipal purposes as indicated since.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Date April 20, 1970

Donald Driscoll
(Signature)

DONALD DRISCOLL, Deputy Chief Engineer
Water Resources Commission

*File in
City of Madison
W.R. File*

AN EVALUATION OF THE POTENTIAL
OF LAND APPLICATION BY IRRIGATION
FOR MUNICIPAL EFFLUENT
AT
MADISON, SOUTH DAKOTA



by

S.D. Department of Agriculture
Division of Conservation

April, 1979

INTRODUCTION

First of all, in dealing with the treatment and disposal of municipal effluent by irrigation, considerations must be dealt with which maintain production of the land indefinitely without deterioration of its potential. These considerations are used in all studies of soil/water compatibility regardless of where the water comes from. Certain other considerations may be necessary when studying effluent application to the land such as the effects of toxic heavy metals and/or the effects of large applications of water per year. However, as long as alternatives are available for the disposal of the effluent, this alternative must be looked at from an agricultural and agronomic point of view. If disposing of municipal waste waters is compatible with the land to which it is applied and needed, then two problems are solved with one solution. However, if the two are not compatible and "disposing of the effluent" overshadows the agricultural consideration, the problems will just be multiplied.

The parameters to look at in making an evaluation of the suitability of this effluent for irrigation are:

1. The soil--its parent material, substratum, internal drainage, acreage
2. The water - salt content, sodium content, heavy metals, quantity
3. The climate - how much precipitation, when does it come; temperatures
4. The crops - management practices, type of agriculture

After these and other physical factors are researched, an intelligent decision can be made which determines whether the land can sustain continuous irrigation.

SOIL INFORMATION

There are many varied soils in the areas under consideration for irrigation in the Madison area. Unfortunately, the pattern and kinds of soils are very similar throughout the five-mile radius of Madison. Consequently, the area which will be considered is somewhat adjacent to the city's lagoon, and the legal descriptions are Sections 9, 10, 11, 14, 15, 16, 18, 19, T106N, R52W and Sections 13, 24, T106N, R53W. See Appendix A.

The types of soil series have been classified into the following categories of suitability for irrigation with this water with their intake rate in inches per hour.

<u>Good</u>	<u>Fair</u>	<u>Marginal</u>	<u>Poor</u>
Dempster sl(0.5)	Graceville sicl(.5)	Ethan loam(.3)	Rauville sicl(NS)
Enecl loam(0.5)	Wentworth sicl(.5)	Egan sicl(.3)	Worthing sicl(NS)
Henkin loam(1.5)	Houdek loam(.3)	Prosper loam(.5)	Tetonka sil(NS)
Delmont loam(1.0)		Viborg sicl(.5)	Lamo sicl(NS)
		Beadle cl(.3)	Badus sicl(NS)
			Whitewood sicl(NS)
			Talno loam (steep)(NS)
			Stickney sicl(.1)
			Sinai sic(.1)

NS = Not suited

The extent of these soils is approximately 25% poor soils, 39% marginal soils, 25% fair soils, and 11% good soils of the 10 sections under consideration. The pattern is about what is normal for most of Lake County. The undulating topography insists upon depressions, drainage-ways, and low grounds along with the uplands, toeslopes, and terraces.

Consequently, the areas are very intermingled and intertwined. The poor soils are defined as low lying soils formed in clayey alluvium or lacustrine clay over glacial till or sand and gravel. Included in this category are the Talmo soils which are steep soils with a thin mantle overlying sand and gravel. The marginal soils are defined as those soils in lower lying positions or slopes which have silty clay loam, clay loam, or clayey subsoils which limit permeability. These soils are limited to waters of low salinity and low sodium.

The fair soils are defined as those soils on an upland position and those soils with gravel subsoils at 40-70". These soils have formed in a thick mantle of silty material over glacial till or sand and gravel. These soils are generally suited to low-medium salinity waters and low sodium.

The good soils are defined as well-drained, silty soils moderately deep over sand and gravel. These soils are suited to medium salinity and low-medium sodium waters. Higher salinity waters may be used if extra water is applied for leaching purposes.

As can be seen from Appendix A, the pattern of soils in the area of concern is limited to the number of areas which can accommodate a center pivot irrigation system of substantial acreage. Even in the few areas which can accommodate such a system, boundary lines of ownership may be a problem. The pink shaded areas are those soils which are classified as "not suited for surface irrigation" by the Soil Conservation Service.

WATER QUALITY

The water quality data which includes the irrigation parameters

needed to make an assessment of the suitability of Madison's stabilization pond effluent for irrigation seems to be very minimal. In fact, the only data obtained is in a report by Odens (3) in assessing lagoon effluents for irrigation. Samples of effluent on numerous stabilization ponds were collected during the summer months of 1975 to determine their suitability for irrigation. In view of the limited data, the South Dakota Department of Agriculture requested a sample of the effluent be taken to substantiate these values. Mr. Dale Carlson, Superintendent of the Waste Water Treatment Plant at Madison agreed to collect a sample of the effluent being discharged and sent the sample to the Water Quality Lab, SDSU, Brookings, S.D. The results of this analyses and the 1975 analyses are stated below and in Appendix B.

MADISON, S.D. WASTE WATER LAGOON EFFLUENT QUALITY

<u>Analysis</u>	<u>July 15, 1975</u>	<u>Aug. 5, 1975</u>	<u>March 19, 1979</u>
Electrical conductivity ($\mu\text{mhos/cm}$ @ 25°C)	2792	2655	2391
Cations (me/l)			
Na	13.91	13.57	12.96
Ca + Mg	12.80	12.40	11.55
K	0.11	0.11	0.52
Anions (me/l)			
CO_3	2.48	0	0
HCO_3	0.80	3.50	3.12
NO_3	0.02	0.01	0.15
SAR	5.50	5.45	5.40
Adjusted SAR	12.85	12.83	12.30

The main parameters to look at in these analyses are the Electrical Conductivity (EC) or total salt load, and percent sodium. The analyses show 2655 and 2792 $\mu\text{mhos/cm}$ for salinity and 52 and 52.3% of the cations

are sodium. Appendix C gives the standards which are being used by the State Conservation Commission for assessing S.D. waters for irrigation. For the "good" soils, the maximum limit for salinity is 2200 $\mu\text{mhos/cm}$ considering the frost-free rainfall of 18". The "poor" soils have a maximum limit ranging from 1300-1800 $\mu\text{mhos/cm}$.

Salt Hazard

Total salts cause a reduced availability of the amount of water which is in storage. The ability of a plant to take up water is dependent upon a gradient which pulls water from the soil. As salt levels are increased in a solution, the amount of energy needed to separate pure water from the salt increases. The plant will be stressed in an effort to take up the water. Therefore, the plant suffers from the lack of sufficient water to maintain high yields.

The EC of the two samples from Madison's effluent are 2655 and 2792 $\mu\text{mhos/cm}$ at 25°C. These both fall into the very high salinity category as shown in red on the chart adapted from the Agricultural Handbook 60, (5) in Appendix E. However, if high pressure center pivot irrigation systems are utilized for application, evaporation losses of the water between the time the water leaves the nozzle and the time it reaches the crop varies from 5-30% (6).

If the evaporation losses averaged 10% over the irrigation season, then the amount of water is reduced by 10% but the salts are not. Thus, there is a concentrating effect before it gets into the root zone. Rather than using 2655 and 2792 $\mu\text{mhos/cm}$ water, it is $2655/.90 = 2950$ $\mu\text{mhos/cm}$ and $2792/.90 = 3100$ $\mu\text{mhos/cm}$. This is why gravity and flood methods of water application are more advantageous than sprinkler methods in

dealing with marginal quality waters for irrigation. In addition to this, any quantity of water to be disposed of would be reduced by 10%.

Sodium Hazard

The sodium hazard causes a lack of water to the plant just as total salinity does, only for a different reason. The sodium in the water, if available in sufficient quantity, reduces permeabilities in soils thereby reducing the amount of water placed in storage, in turn causing a shortage of water to the plant. The sodium hazard is calculated by the Adjusted Sodium Adsorption Ratio. This ratio is a measure of the tendency of soil colloids to accumulate sodium ions taking into consideration the effect of carbonate and bicarbonate precipitation of calcium and magnesium. This ratio is calculated by the following equation:

$$\text{Adj. SAR} = \frac{\text{Na}}{\sqrt{\frac{\text{Ca} + \text{Mg}}{2}}} [1 + (8.4 - \text{pH}_c)]$$

Ca, Mg, and Na are expressed in milliequivalents per liter.

pH_c is a theoretical, calculated pH of the irrigation water in equilibrium with calcium carbonate.

The adjusted SAR of the Madison waste water is 12.8. This value very closely correlates with the exchangeable sodium percentage (ESP)* of 12.8 on the soil surface. According to Rhoades and Merrill (4) "for soil related sodicity considerations, EC_{iw} [electrical conductivity irrigation water] and SAR_u [adjusted sodium adsorption ratio] are recommended to use to assess the likelihood of significant permeability reductions for a soil of given EC-ESP (or SAR) tolerances". However, field data gathered by the S.D. Department of Agriculture for the past two years

*ESP--the percent of sodium ions compared to allocations which occupy exchange sites in soils.

indicate that .7 times the adjusted SAR may represent a better ESP of the soil surface for S.D. soils. Some soils may have the ability to buffer the sodium affect more than others due to the lime content, organic matter and different mineralogy. Since the data are limited, a separate determination of the effects of sodium on each soil type cannot be made to date. If the ESP of the soil surface eventually reached 9% ($12.8 \times .7$) management problems could very likely develop. Cases in S.D. have shown that soils which have reached 9-10% ESP due to irrigation with sodic water have become difficult to work. Hard clods and poor tilth have resulted in poor seed beds and poor germination. A soil classified as a sodic or alkali soil is one with an ESP of 15% or more.

A more hazardous sodic problem may develop below the surface as the sodium concentration increases with depth. This is controlled mostly by the leaching fraction which in turn is limited by the hydraulic conductivity of the subsoil. If soil amendments are used to improve permeabilities as sodium problems develop, the amounts to apply and the time recommended to counteract the sodium problem would depend on the depth to the most affected layer, the amount of sodium to remove, and the contact time between the amendment and the soil.

Specific Ion Toxicity

The high levels of chloride in this water (12.32 milliequivalents per liter) may cause severe leaf burn on some crops when using sprinkler irrigation due to the concentrating effect of water evaporating from leaf surfaces. Crops which are more tolerant of this effect must be chosen to reduce a problem of this nature.

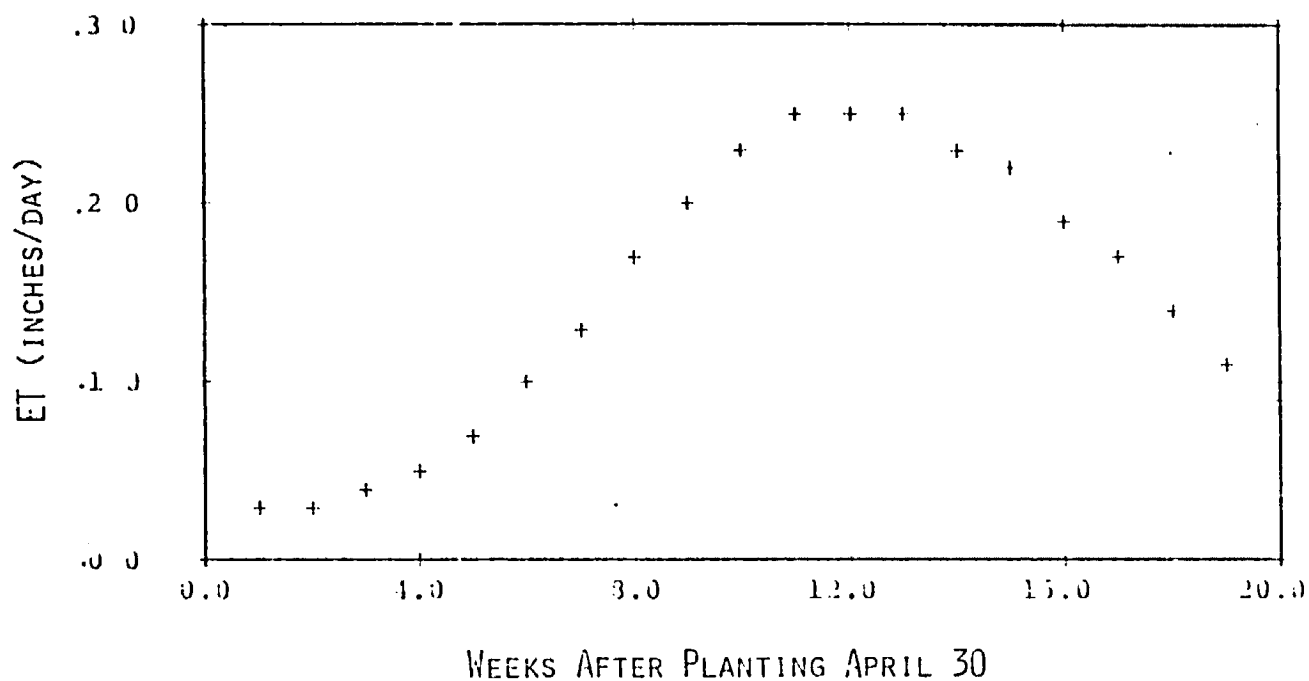
CLIMATIC FACTORS

Precipitation

The average yearly precipitation and temperature records for the years 1967-1978 for the Madison Research Farm and Wentworth are presented in Appendix D. Wentworth weather station is closer to the area under consideration and the records show that the average annual precipitation for that period is 22.09 inches. The average annual precipitation for the period 1941-1970 shows 24.34" (2). The average growing season precipitations (April through September) are 15.52" for '67-'78 and 18.61" for '41-'70. When considering disposing of effluent on the land the average annual precipitation received (22") is used in calculations. A safety factor should also be included in the design calculations to accommodate the wet years as well as the average. If the additional precipitation received in wet years falls during the growing season, consideration should be given to the reduction of the total amount of water to apply. This total amount will have to be lost due to runoff, evapotranspiration, or deep percolation.

The mean temperatures by months are also listed in Appendix D. Using the mean daily temperature of 32°F or greater as a basis for determining the number of days when waste water can be applied may be satisfactory for rapid infiltration-percolation systems but is not valid when considering irrigation. Usually the months of March, April, and May are periods of dealing with snow melt and spring precipitation. Farmers often have difficulty in planting crops during this time frame. In addition to this, evapotranspiration rates are very low. Consequently, this would hardly be a time period when a farmer would be willing to add 3" of water

AVERAGE DAILY CONSUMPTIVE USE FOR CORN



AVERAGE DAILY CONSUMPTIVE USE FOR ALFALFA (ADJUSTED FOR 3 CUTTINGS)

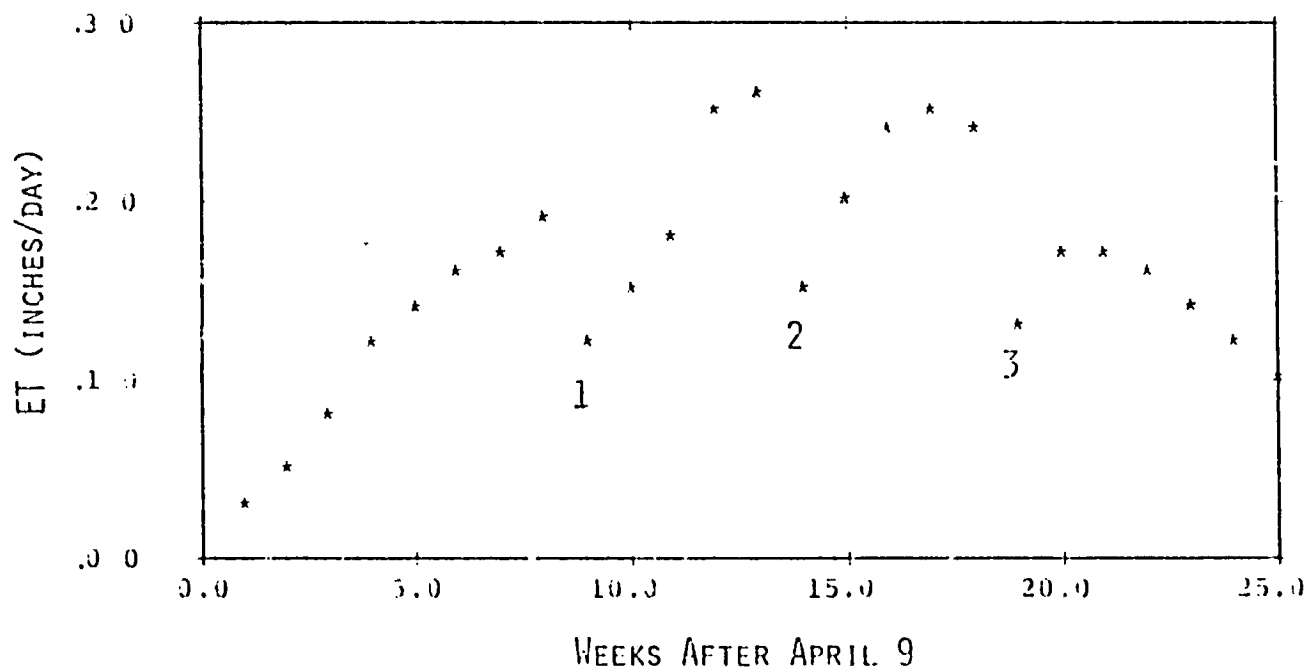


Figure 1. Average daily consumptive use for corn and alfalfa at Madison, S.D.

per week. There may be occasions when water is used to germinate crops and this could even be common practice if rainfall is not available. However, the overall irrigation regime should coincide with the consumptive use pattern of the crop as shown in Figure 1. The irrigation should start with amounts which keep the soil profile near field capacity but not saturated. As ET rates increase, the amounts to apply increase. The area under the curve equals the total amount of water used in ET. For corn the total is approximately 21" from April 30th through September 16 and for alfalfa the total is 28" from April 9th through September 30th (1) for the area in question. The pattern of application, therefore, should increase slowly to a peak and then taper off toward the end of the season. Consequently, the application period should not exceed 125 days. This would be an operational period of June 1 through October 3. Consideration should also be given to times when field operations are necessary. Applications should cease for a period of time prior to these operations to prevent adverse effects on the crop, the land, and the farmer.

AGRONOMIC CONSIDERATIONS

Crop Suitability

The crop or crops to be used in this land application should be chosen carefully to tolerate the possible toxic effects of the water. In this case, the total salt content of the water is very high. Consequently, salt tolerant crops must be selected which can still maintain satisfactory production. Below are listed some crops and grasses with their tolerance levels.

<u>Crop</u>	<u>% Yield Reduction Possible</u>		<u>Max (100%)</u>
	<u>0% (Threshold)</u>	<u>25%</u>	
Barley	8000	13,000	28,000
Wheat	6000	9,500	20,000
Soybean	5000	6,200	10,000
Corn	1700	3,800	10,000
Tall wheat grass	7500	13,300	31,500
Tall fescue	3900	8,600	23,000
Reed canary grass	4500	---	20,000
Alfalfa	2000	5,400	15,500

Figure 2. Yield decrement to be expected due to salinity of irrigation water using surface irrigation. Values are salinity of saturation extract (soil) in umhos/cm. [Adapted from data reported by Maas and Hoffman (in press), Bernstein (1964), and University of California Committee of Consultants].

The EC of Madison's waste water would be about 2900 if high pressure sprinkler systems were used and salinity progressively increases with depth depending upon the amounts of rainfall received during the application periods. As can be seen from the chart, corn and, to some extent, alfalfa are not very salt tolerant. Since the threshold salinity value for both crops is below the conductivity value of the water, yield reductions can be assured if these crops are chosen. The salinity level at lower depths will increase and only the rate of accumulation is dependent upon what leaching fraction is used and the amount of rainfall received.

Management Practices

In dealing with management of the land a number of factors should be considered. The crop or crops should:

1. have a high water uptake requirement
2. be able to take up the amounts of nitrogen and phosphorus in the water for the land area required
3. require minimal field operations
4. help to increase intake rates yet maintain stability for continuous move irrigation systems

5. help to keep erosion to a minimum if slopes exceed 2%
6. require a fairly low level of intensity for management
7. have a tolerance to the salt levels expected in the soil S
8. be somewhat tolerant of specific ion toxicity by foliar absorption.

Some of these considerations may have to be sacrificed for the sake of others. However, 4, 5, 7 and 8 are very important in maintaining the soil and adequate crop production.

Hydraulic Loading

In determining a figure for the amount of water to apply to the land and yet maintain good crop production, a good estimate must be made of the ET, runoff (if any will be tolerated), and deep percolation. These are the only means of disposing of the water once it is applied.

Hopefully the only runoff will be lost in the spring due to snow melt. This may be 2-4" depending upon how full the profile is when the melt occurs. If the profile is full, the beneficial dilution of natural precipitation is lost to runoff which in turn may cause an erosion problem. If alfalfa is used as a crop, the ET for that crop in the Madison area will be approximately 28-30" (the area under the curve, Figure 1) from April 9th through September 30th.

The amount of leaching which the soils under consideration can permit is variable. The soils classified as "good soils" may be able to allow a maximum of .3-.4 as a leaching fraction* if a water table does not develop. The "fair soils" may allow a .2-.3 leaching fraction with some variations in the soils within this category. The marginal soils may permit leaching fractions of .1-.2 and may reach .25 if tile drains are installed to relieve water table problems. The poor soils should be

*Leaching fraction is the ratio of the amount of water lost as drainage water to the total amount of water applied.

avoided altogether in considering irrigation even with tile drains. Their reduced permeabilities at lower depths would cause eventual salt accumulations.

Consequently, with maximum leaching fractions ET rates, and runoff known, the amount of water to apply can be calculated.

$$\text{Amount in} = \text{Amount out}$$

$$\text{Precipitation} + \text{irrigation water} = \text{ET} + \text{runoff} + \text{drainage}$$

ET = 30", (alfalfa) runoff is assumed to be 4", and precipitation is 22"

$$\therefore 22" + \text{IW} = 30" + 4" + \text{drainage}$$

$$\text{IW} = 12" + \text{drainage}$$

Drainage is calculated as .3 (reasonable LF) times the amount of water received by the land, or IW + Precip. Then,

$$\text{IW} = 12" + .3(\text{IW} + 22")$$

or

$$\text{IW} - .3(\text{IW}) = 12 + 6.6$$

$$\text{IW} \approx 27"$$

If an average of 10% of this water is lost to evaporation by sprinkler application then this figure can be increased to

$$27/.9 = 30"$$

This calculation was based on all the soils having a LF of .3. However only the "good and fair soils" will be able to maintain this LF. The figure of 30" will be used as the number of inches of irrigation water to apply annually. Twenty inches annually was the figure arrived at for disposing of the effluent from the lagoon at Mitchell, S.D. The total amount of water which the land will receive in a year will average 52" and will approach 60" in wet years.

LAND REQUIREMENTS

Irrigation

The area required to dispose of 30" annually at a design rate of one million gallons per day (MGD) or 2 MGD (future use) is given below.

$$\frac{3.067 \text{ acre-feet} \times 1.0 \text{ MGD} \times 365 \text{ days}}{1 \text{ million gal.}} = 448 \text{ acres}$$

30"/12

$$\frac{3.067 \text{ acre-feet} \times 2.0 \text{ MGD} \times 365 \text{ days}}{1 \text{ million gal.}} = 896 \text{ acres}$$

30"/12

Land area required for 30" per year is approximately 450 acres for 1 MGD and 900 acres for 2 MGD.

Storage Requirement

Using a 125 day operational period of application of waste water, the land area required would be the amount of flow per day into the lagoon times the number of days needed for storage, or 240 days.

$$\frac{3.067 \text{ acre-feet} \times 1.0 \text{ MGD} \times 240 \text{ days}}{1 \text{ million gal.}} = 736 \text{ acre-feet}$$

$$\frac{3.067 \text{ acre-feet} \times 2.0 \text{ MGD} \times 240 \text{ days}}{1 \text{ million gal.}} = 1472 \text{ acre-feet}$$

If a storage pond were 10' deep this would require 74 acres for 1 MGD and 148 acres for 2 MGD.

RECOMMENDATION

In view of the facts presented in this report, land application by irrigation of the effluent from the city of Madison, S.D. is not a viable alternative for the reasons as summarized.

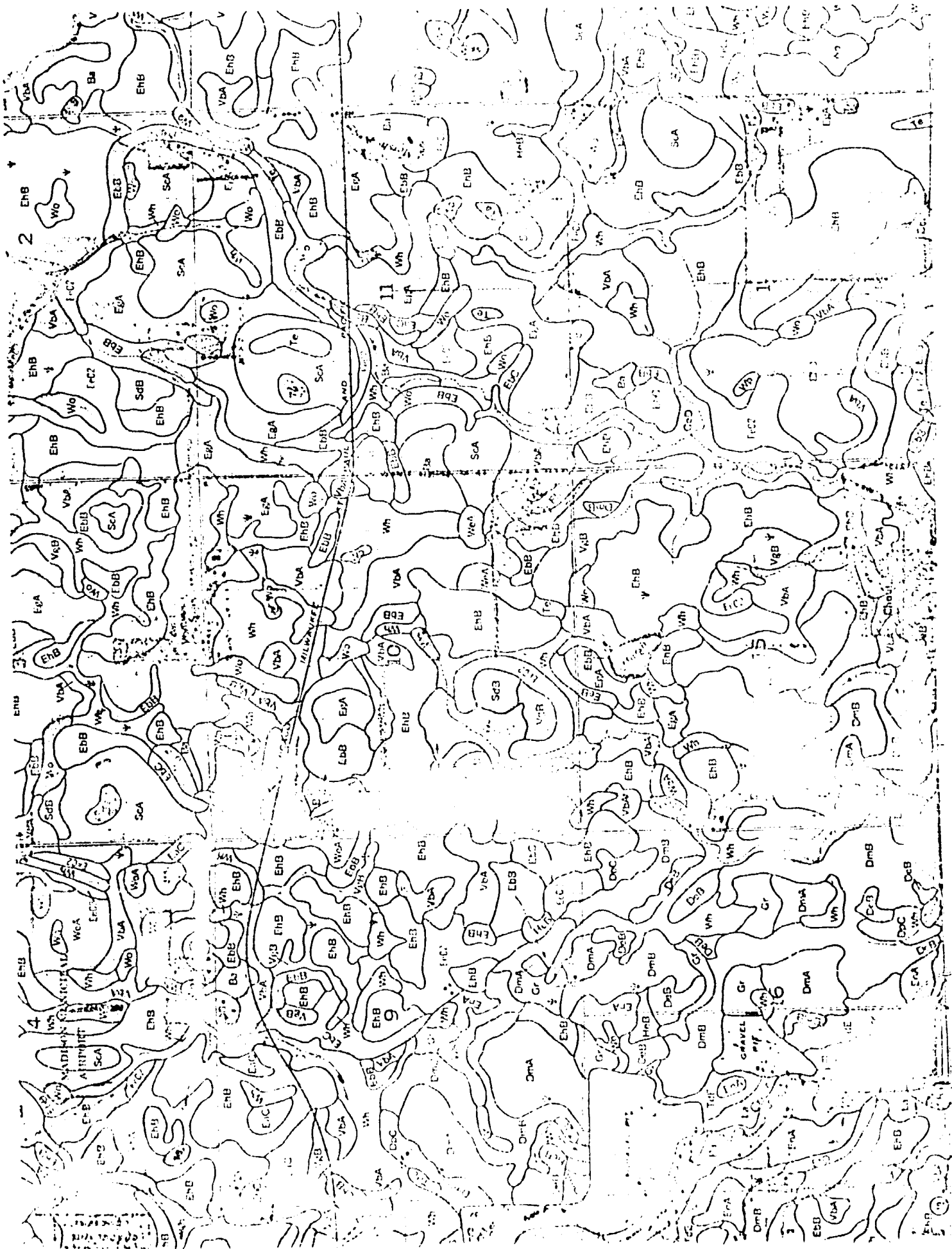
1. The suitable land area required for proper disposal of the

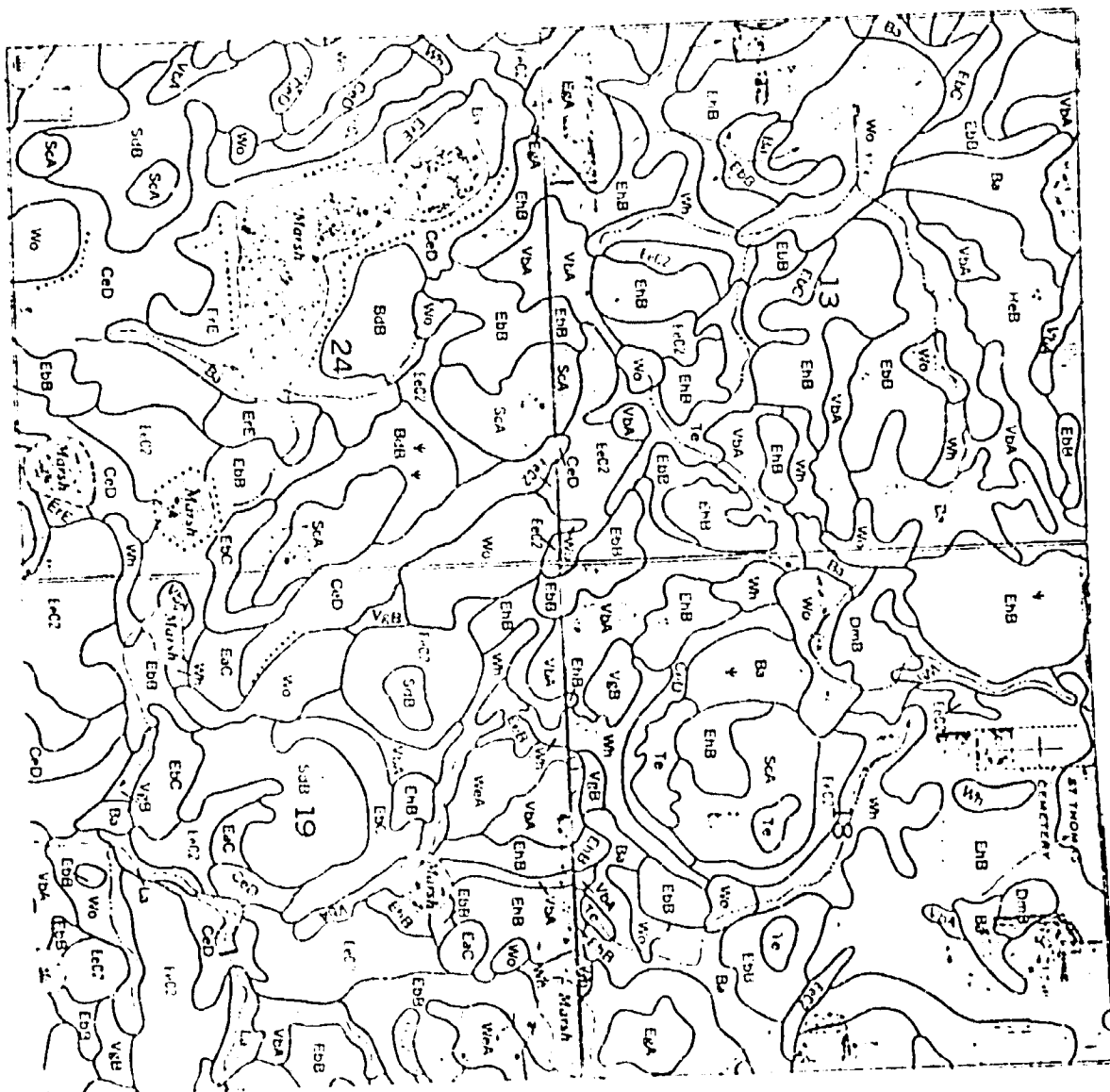
water by irrigation is not available in the areas under consideration. The good and fair soils in close proximity to the lagoon amount to, at the most, 300 acres. In addition, of this 300 acre area, only approximately 160-200 acres would be suitable for center pivot irrigation depending upon whether the corners were watered. This would have to be done with 3-4 different systems.

2. If some of the marginal soils are irrigated with this water, the combination of slope ($>2\%$) and reduced permeabilities would almost assuredly cause runoff and eventual salinity increases. Crops in the low lying areas would suffer or die due to reduced aeration caused by ponding runoff waters. When the soil profile is at field capacity, the application of more water will create a magnified effect of what has become evident on these soils in wet years. Almost twice as much water as has ever been received in this area must be dealt with.
3. If tile drains are installed to alleviate some of these problems, an additional problem of trying to dispose of the drainage water, which would be 4 times as salty as the input water, is created. In addition, the cost of installing tile drains would probably more than double the cost of the irrigation project.

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5. United States Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. U.S. Dept. Agr. Handbook 60. 160 pp.
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APPENDIX A

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, or F, shows the slope. Symbols without a slope letter are those of nearly level soils. A final number, 2, in the symbol indicates an eroded soil.

SYMBOL	NAME
Ba	Badus silty clay loam
Bc	Baltic silty clay loam
BdA	Beadle clay loam, 0 to 2 percent slopes
BdB	Beadle clay loam, 2 to 6 percent slopes
BdC	Beadle clay loam, 6 to 9 percent slopes
CaA	Clarno loam, 0 to 2 percent slopes
CaB	Clarno loam, 2 to 6 percent slopes
CaC	Clarno loam, 6 to 9 percent slopes
CeB	Clarno-Ethan loams, 2 to 6 percent slopes
CeC	Clarno-Ethan loams, 6 to 9 percent slopes
CeD	Clarno-Ethan loams, 9 to 16 percent slopes
Da	Davis loam
DeB	Delmont-Talma loams, 2 to 6 percent slopes
DeC	Delmont-Talma loams, 6 to 9 percent slopes
DwA	Dempster silt loam, 0 to 2 percent slopes
DwB	Dempster silt loam, 2 to 6 percent slopes
DwC	Dempster-Delmont complex, 6 to 9 percent slopes
EaC	Egan silty clay loam, 6 to 9 percent slopes
EbA	Egan-Beadle complex, 0 to 2 percent slopes
EbB	Egan-Beadle complex, 2 to 6 percent slopes
EbC	Egan-Beadle complex, 6 to 9 percent slopes
EcA	Egan-Ethan complex, 2 to 6 percent slopes
Ec2	Egan-Ethan complex, 6 to 9 percent slopes, eroded
EgA	Egan-Viborg silty clay loams, 0 to 3 percent slopes
EtB	Egan-Wentworth silty clay loams, 2 to 6 percent slopes
EnA	Ener loam, 0 to 2 percent slopes
EtF	Ethan-Betts loams, 21 to 40 percent slopes
EtE	Ethan-Clarno loams, 15 to 21 percent slopes
EsE	Ethan-Clarno stony complex, 6 to 25 percent slopes
EtD	Ethan-Davis stony complex, 3 to 21 percent slopes
Gr	Graceville silty clay loam
HeA	Herkim loam, 0 to 3 percent slopes
HeB	Herkim loam, 3 to 9 percent slopes
HkB	Houdek loam, 2 to 6 percent slopes
HpA	Houdek-Prosper loams, 0 to 3 percent slopes
La	Lamo silty clay loam
MnB	Moody-New complex, 2 to 6 percent slopes
MrA	Moody-Trent silty clay loams, 0 to 2 percent slopes
NcC	Nora-Crofton silt loams, 6 to 9 percent slopes
PrA	Prosper loam, 0 to 2 percent slopes
Ra	Rawlitz silty clay loam
Sa	Sandy lake beaches
ScA	Sinal silty clay, 0 to 2 percent slopes
SdA	Sinal silty clay loam, 2 to 6 percent slopes
StA	Stickney-Terunka complex, 0 to 2 percent slopes
TdE	Talmo-Delmont loams, 6 to 21 percent slopes
Te	Terunka silt loam
VbA	Viborg silty clay loam, 0 to 2 percent slopes
VgB	Viborg-Egan silty clay loams, 2 to 6 percent slopes
Vo	Volga silty clay loam
WtA	Wentworth-Egan silty clay loams, 0 to 2 percent slopes
Wh	Whitewood silty clay loam
Wo	Writhing silty clay loam

Figure 3. Soils legend for Figures 1 and 2.

REPORT OF ANALYSIS
 Water Quality Laboratory
 Water Resources Research Institute
 South Dakota State University
 Brookings, South Dakota 57007

APPENDIX B

Submitted by: City of Madison
 Address: Madison, SD 57042

Date Rec'd March 19, 1979
 Sample No. 79-119
 Identification Wastewater treatment

WATER ANALYSIS

Calcium (Ca)	149	ppm*	7.45	me/l**
Magnesium (Mg)	50	ppm	4.10	me/l
Sodium (Na)	298	ppm	12.96	me/l
Potassium (K)	20	ppm	0.52	me/l
Sulfate (SO ₄)	490	ppm	10.19	me/l
Nitrate (as N)	2.05	ppm	0.15	me/l
Chloride (Cl)	440	ppm	12.32	me/l
Bicarbonate (HCO ₃)	190	ppm	3.12	me/l
Carbonate (CO ₃)		ppm		me/l
Iron (Fe)		ppm		me/l
Fluoride (F)		ppm		me/l
Hardness (EDTA as CaCO ₃)		ppm		g.p.g.***
Alkalinity (Methyl Orange)	156	ppm (as CaCO ₃)		
Alkalinity (Phenolphthalein)	0	ppm (as CaCO ₃)		
Electrical Conductivity	2391	micromhos per cm at 25° C.		
Sodium Adsorption Ratio	5.40	Adjusted SAR	12.30	
Sodium	51.80	% of cations		
Residual sodium carbonate	0.00	me/l		
pH	6.90			

Others:

*ppm=parts per million

**me/l=millequivalents per liter

***g.p.g.=grains per gallon

COMMENTS: Total cations 25.03 me/l
 Total anions 25.78 me/l

By: Shirley Mittan

Service Performed	Amount Due
Irrigation analysis	

Make checks payable to: Water Quality Laboratory

Cut along dotted line and return the lower portion with payment

Sample No. 79-119

Amount Enclosed \$ _____

Signed _____

WATER QUALITY STANDARDS
FOR SOUTH DAKOTA IRRIGATION WATERS
A REVISED 1/23/79[†]

MAXIMUM ALLOWABLE SALINITY*(ECx10⁶) AND SODIUM (SAR) VALUES**
PERMISSIBLE FOR WATERS

Soil textures***	Adjusted SAR**** of water x 0.7 ⁺⁺	40 inches or less to more permeable material	40 inches to 72 inches to more permeable material	20 inches to 60 inches to less permeable material
		6 ECx10	6 ECx10	6 ECx10
Loamy sands and sandy loams	>6	2500	2200	1700
	6 - 8	2200	2000	1400
	8 - 11	1900	1700	1100
Loams, silts and silt loams	>6	2300	1900	1500
	6 - 8	2000	1600	1000
	8 - 11	1600	1200	750
Sandy clay loams Silty clay loams and clay loams	>6	1800	1600	1400
	6 - 8	1500	1300	900
Silty clays, sandy clays, and clays	>6	1600	1400	1200
	6 - 8	1400	1200	800

*The ECx10⁶ values are based on 12 inches or less of average rainfall during the frost free season. For each additional 2 inches of rainfall during this period, the permissible ECx10⁶ values may be increased by 200 for all categories.

**Waters with adjusted SAR >16 are unsuitable under all conditions.

***Adequate internal drainage must be absolutely assured for all textural groups. Subsurface drains may be needed if a detrimental high water table develops. Texture indicated pertains to the solum. Soils with a textural B horizon are a special consideration.

$$****\text{Adj. SAR} = \frac{\text{Na}}{\sqrt{\frac{\text{Ca} + \text{Mg}}{2}}} [1 + (8.4 - \text{pHc})]$$

†These standards are subject to revision within two years after adoption and bi-annually thereafter as more research information becomes available.

++An empirical factor which incorporates climatic and soil weathering effects.

WENTWORTH 2 MI. MNW

	Precipitation (inches)												Annual
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1978	0.14	0.42	0.50	3.63	3.00	0.66	4.07	2.06	2.96	0.10	0.73	0.46	18.73
1977	0.28	0.99	4.16	1.00	2.19	2.67	1.91	-----	3.04	2.71	2.39	0.85	27.19
1976	0.55	0.86	1.45	1.94	0.37	1.79	1.35	0.67	2.00	0.46	0.01	0.30	11.74
1975	1.55	0.21	2.28	2.23	2.15	4.52	1.57	6.97	2.04	0.20	1.54	0.20	25.46
1974	0.05	0.99	1.87	1.40	3.97	2.50	1.31	6.81	0.24	0.70	0.29	0.20	20.33
1973	0.58	0.77	3.11	1.51	1.43	1.34	1.32	1.85	5.05	2.59	0.65	0.86	21.06
1972	0.10	0.35	1.10	1.67	9.30	2.32	6.73	2.00	1.97	-----	1.20	2.14	28.88
1971	0.06	1.46	0.89	1.99	1.49	3.56	2.60	2.60	1.83	4.21	2.51	0.72	23.92
1970	0.18	T	2.84	3.19	3.19	2.97	2.35	1.53	1.49	2.99	1.78	1.00	23.51
1969	1.26	2.80	0.43	0.66	2.63	2.29	1.57	2.46	1.84	2.75	0.39	0.74	19.82
1968	0.36	0.06	1.34	4.41	2.17	5.69	1.83	1.79	3.28	3.77	0.36	2.02	27.08
1967	0.68	0.76	0.16	2.64	0.66	5.75	1.17	2.98	1.01	0.94	0.11	0.41	17.29
High	1.55	2.80	4.16	4.41	9.30	5.69	6.73	6.97	5.05	4.21	2.51	2.14	28.88
Low	0.06	T	0.16	0.66	0.37	0.66	1.17	0.67	0.24	0.10	0.01	0.20	11.75
Mean	0.48	0.81	1.68	2.19	2.71	3.01	2.32	3.06	2.23	1.91	1.00	0.83	22.09

15.52

Monthly Mean Temperature (°F)

1978	2.7	8.9	30.7	45.1	58.6	68.1	72.0	71.7	67.6	50.0	30.5	14.3
1977	4.7	26.2	35.1	53.7	66.0	69.8	76.1	-----	61.9	48.1	29.9	15.7
1976	14.3	29.4	33.5	51.8	57.4	70.7	76.0	74.5	63.3	44.1	27.4	16.7
1975	17.0	15.3	24.5	39.9	60.5	67.1	75.7	71.0	57.5	52.3	34.7	19.3
1974	14.2	23.5	33.9	48.8	55.7	66.1	76.9	67.4	58.7	52.2	33.9	23.3
1973	18.8	22.9	39.2	46.0	57.5	68.6	72.6	75.0	60.0	54.1	34.0	17.1
1972	8.8	12.8	30.7	44.0	60.0	67.3	70.7	70.4	60.2	-----	31.9	15.4
1971	8.6	18.7	30.6	48.1	55.8	71.5	69.0	72.5	61.7	51.5	34.0	17.1
1970	5.9	20.8	26.7	44.5	60.3	69.7	73.8	72.1	62.8	47.4	31.8	16.9
1969	7.3	19.4	20.2	47.6	60.4	61.5	72.9	72.1	62.8	43.9	34.2	21.0
1968	16.0	17.7	40.7	47.9	53.3	69.2	71.0	72.1	60.2	50.0	34.0	16.0
1967	18.1	15.1	36.3	46.3	54.2	65.7	70.3	68.7	60.3	48.5	32.6	21.3
High	18.8	29.4	40.7	53.7	66.0	71.5	76.9	75.0	67.6	54.1	34.7	23.3
Low	2.7	8.9	20.2	39.9	53.3	61.5	69.0	67.4	57.5	43.9	27.4	14.3
Mean	11.4	19.2	31.8	47.0	58.3	67.9	73.1	71.6	61.4	49.3	32.4	17.8

Table I. Wentworth, S.D. precipitation and temperature data.

MADISON RESEARCH FARM

Precipitation (inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1978	0.13	1.05	0.90	3.92	3.17	0.92	3.76	1.67	2.79	0.14	0.81	0.69	19.95
1977	0.27	1.47	4.73	1.34	2.42	2.88	2.34	5.27	3.31	2.38	2.48	1.54	30.43
1976	0.77	0.96	1.48	2.31	0.37	1.72	0.79	1.14	2.98	0.67	0.10	0.34	13.63
1975	1.60	0.31	2.89	2.03	3.12	5.22	1.55	7.00	2.12	0.52	1.81	0.25	28.42
1974	0.07	0.68	1.71	1.32	4.47	3.15	1.42	4.10	0.21	0.31	0.31	0.29	18.04
1973	0.60	0.87	2.76	1.38	2.40	1.25	1.88	2.62	4.12	3.25	0.86	1.05	23.04
1972	0.02	0.63	1.25	1.72	8.53	1.40	6.85	1.30	1.11	2.00	1.55	1.17	27.53
1971	0.09	1.17	0.92	1.88	1.64	3.33	2.50	3.76	1.04	3.87	2.28	0.64	23.12
1970	0.38	0.01	2.76	3.13	2.14	3.12	2.41	1.07	1.31	3.09	1.71	1.01	22.14
1969	1.38	3.43	0.47	0.96	5.03	2.17	1.81	3.72	1.87	3.36	0.39	0.97	25.56
1968	0.58	0.10	1.15	4.65	1.80	4.78	1.73	1.22	2.83	3.53	0.60	4.39	27.36
1967	0.69	0.89	0.26	1.90	0.85	7.07	1.15	2.66	1.07	1.00	0.12	0.41	18.07
High	1.60	3.43	4.73	4.65	8.53	7.07	6.85	7.00	4.12	3.87	2.48	4.39	30.43
Low	0.02	0.10	0.26	0.96	0.37	0.92	0.79	1.14	0.21	0.31	0.10	0.25	13.63
Mean	0.55	0.96	1.77	2.21	3.00	3.08	2.35	2.96	2.06	2.01	1.09	1.06	23.11

15.66

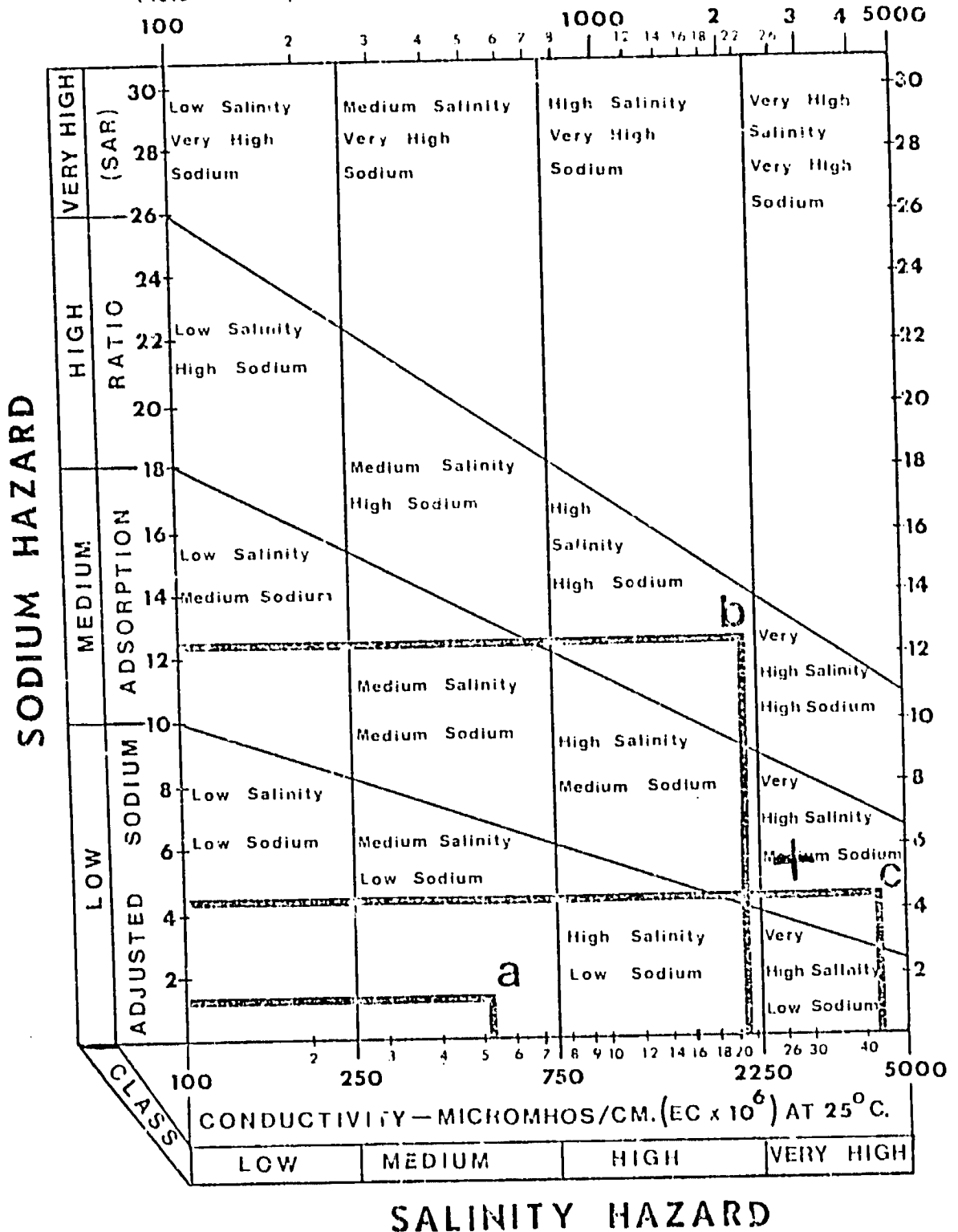
Monthly Mean Temperature (°F)

1978	1.4	7.8	30.4	44.9	58.5	67.5	71.7	71.5	67.9	49.9	31.1	13.9
1977	3.7	26.0	34.8	53.4	66.2	69.5	75.7	67.2	61.9	48.5	29.9	14.8
1976	13.7	29.1	33.2	51.6	58.0	70.6	76.1	75.1	63.6	44.1	27.9	17.4
1975	16.4	14.2	24.2	39.6	60.3	66.7	75.3	71.3	58.1	52.5	34.3	19.6
1974	13.3	22.6	33.6	48.9	55.7	66.7	76.2	66.8	59.0	52.7	34.1	22.8
1973	17.1	21.7	38.7	45.8	57.6	68.5	73.2	74.9	59.7	54.5	33.0	16.5
1972	7.8	11.8	30.7	43.9	59.2	67.6	69.5	70.4	60.3	45.9	30.8	14.3
1971	8.2	17.6	29.4	48.8	56.7	71.2	68.9	72.6	61.7	52.4	32.8	16.4
1970	5.4	21.2	26.0	44.1	60.7	69.3	74.0	73.0	62.9	47.9	31.5	16.5
1969	6.9	18.9	18.9	47.5	59.9	61.7	72.5	72.9	63.0	43.8	34.4	20.9
1968	15.4	17.8	41.1	47.7	53.0	68.5	70.7	72.0	61.2	50.1	34.4	15.8
1967	17.8	15.6	36.3	46.3	54.4	65.5	70.2	69.7	60.1	47.9	32.8	21.3
High	17.8	29.1	41.1	53.4	66.2	71.2	76.2	75.1	67.9	54.5	34.4	22.8
Low	1.4	7.8	18.9	39.6	53.0	61.7	68.9	66.8	58.1	43.8	27.9	13.9
Mean	10.6	18.7	31.4	46.9	58.4	67.8	72.8	71.5	61.6	49.2	32.3	17.5

Table II. Madison Research Farm precipitation and temperature data.

Figure 1. Classification of Irrigation Waters¹

(Note: Examples from Table 1 on page 4 are shown in blue)



¹Adapted From Agricultural Handbook 60, USDA

January 17, 2001

2000 South Dakota Water Use Questionnaire

To:

CITY OF MADISON
PO BOX 308
MADISON SD 57042 0308

Address correction requested:

One questionnaire is being provided for each permitted water source. The following information is based on Water Permit/Right No. 1604-3. If you have other permits/rights in the same water source, also include water use under those permits/rights on this questionnaire.

Water Source: GROUNDWATER

County: LAKE

Aquifer: NIOBRARA FORMATION

Pumping Pt. Legal: SEC 08-T106N-R52W

Management Unit: NOT APPLICABLE

Type of Water Use: MUNICIPAL

1) Please estimate your year 2000 water use from the above water source: 14,100,000 gallons

2) If no water use in 2000, please list the reason(s) why in the comments section.

Comments:

Contact Person:

Jerry Mikel

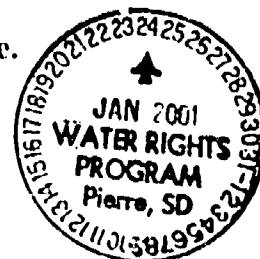
Telephone No:

605-256-7515

Questions? Please call Mark Rath or Ron Duvall at 605 773-3352 for assistance.

Thank you for completing the 2000 water use questionnaire.

Water Rights on the Web: www.state.sd.us/denr/wr





1079-3 1453-3 1604-3 371-1 372-3
6512-3 6511-3 6510-3 747-3 6040-3

**DEPARTMENT of AGRICULTURE
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 E. CAPITOL AVE
PIERRE SD 57501-3182
danr.sd.gov

October 21, 2025

8792-3

City of Madison
c/o Finance Officer
503 S Highland Ave
Madison SD 57042

Attention Finance Officer:

Enclosed is a "Notice" dated October 8, 2025, concerning the 2025 Irrigation Questionnaire.

The notice was originally mailed to the City of Madison at 116 W Center St, Madison SD 57042. The post office notified our office that your address has changed, and your records have been updated accordingly.

This is a time sensitive matter. Please complete and return the enclosed questionnaire or submit your report online at <https://danr.sd.gov/iq/> using this password **FFDLQE**.

If this change of address is in-correct, please contact our office immediately to update your contact information.

Sincerely,

Amanda Dewell
Permitting Administrator
Water Rights Program
605 773-3352
Amanda.Dewell@state.sd.us

enclosures

553 NFE 1 C24C0010/15/25
RETURN TO SENDER
: CITY OF MADISON
503 S HIGHLAND AVE
MADISON SD 57042-3227

RETURN TO SENDER