ASSESSMENT OF POTENTIALLY IRRIGABLE LAND IN THE AREA OF THE WARWICK AQUIFER IN BENSON, EDDY, AND NELSON COUNTIES, ND

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INTRODUCTION

In 1995 a general inventory of acreage potentially suitable for irrigation was conducted for eighteen counties in central North Dakota (Olson and Schuh 1995). The purpose of the inventory was to identify general areas for further assessment, and to provide a conservative estimate of gross acreage that might be available for development. A more detailed inventory of acreage potentially suitable for irrigation was published for eastern McLean County in 1998 (Schuh 1998). The purpose of this report is to assess acreage for potential irrigation development from ground-water sources in southern Benson County, northern Eddy County, and western Nelson County, in the area of the Warwick aquifer. The area evaluated consists of six townships, including townships 150 N, and 151 N, for ranges 61 W, 62 W, and 63 W, and is bounded approximately by the east end of Devils Lake on the north, Stump Lake on the northeast, the Sheyenne River on the south, and Horseshoe Lake on the west (Figure 2). Platt map townships included are Freeborn and Eddy townships in Eddy County, Minco and Warwick townships in Benson county, and Leval and Dayton townships in Nelson County.

Methods for determining irrigable soils are conservative. Forty-acre land tracts are evaluated for soil series without major irrigation limitations. Screening for land tracts having irrigable series was based on soil maps in the Benson, Eddy, and Nelson County Soil Surveys (USDA 1979, 1977, and 1989 respectively). Potential water supplies are evaluated on a section scale, using the North Dakota county studies for Benson County (Randich 1977), Eddy County (Trapp 1968), and Nelson County (Downey 1973). Potentially irrigable tracts are identified for further and more detailed examination by landowners wishing to develop for irrigation. **While the scale of analysis is detailed, and while all mapped locations identified should be promising prospects for future development, it is stressed that actual development should always be preceded by detailed on-site examination for all essential properties. Aquifer maps and soil maps provide good indicators of potential water and soil availability, but they are not without error, and in a heterogeneous environment they can be mistaken or oversimplified at some locations. In particular, water quality must be examined locally.** Based on the distribution of water quality (sodium adsorption ratio and electrical conductivity) samples from the Warwick and Spiritwood aquifer systems in the study area, most wells should provide water suitable for irrigation.

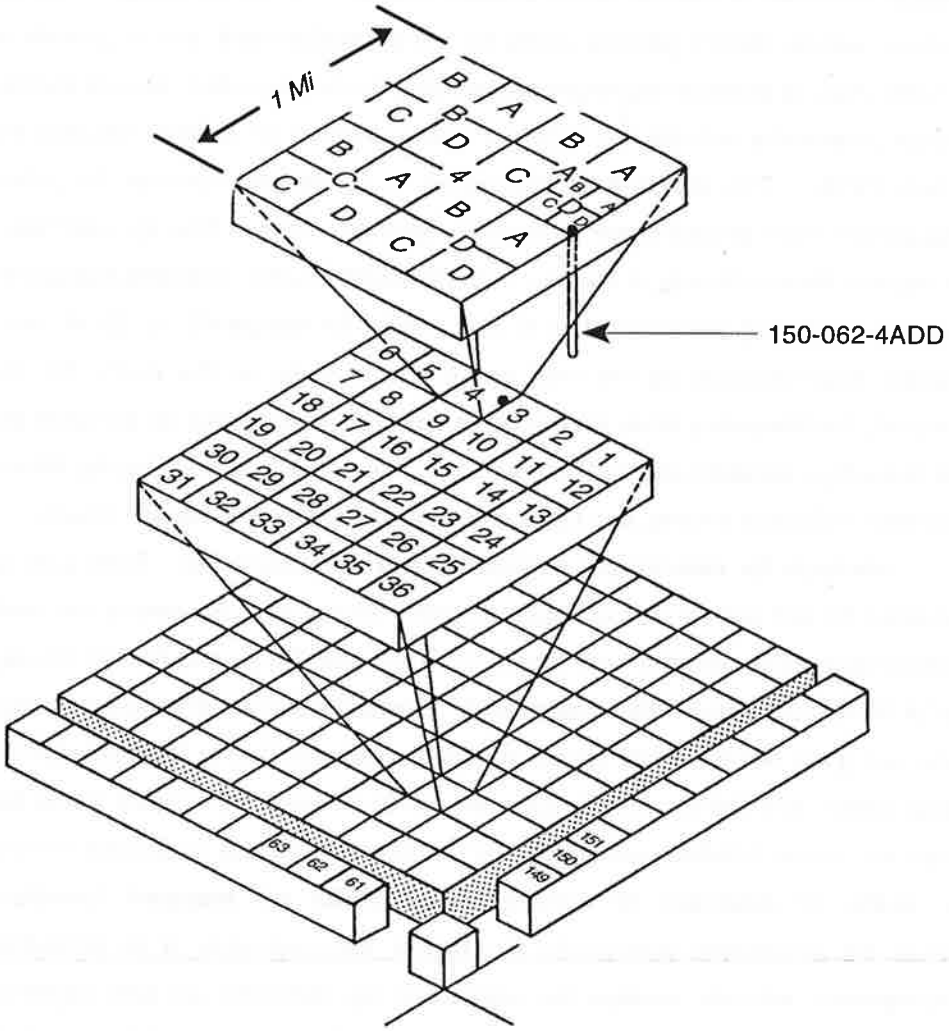

Figure 1. Illustration of map location and numbering system.

IDENTIFICATION OF LAND TRACTS

The scale used in this report for identification of potential irrigable lands is a 40-acre tract. The soil series are identified specifically on each tract. Water availability is based on a broader criterion: whether a suitable supply is likely to be found at some location on the section in which the tract is located. These criteria are described in more detail below. Actual tract units are identified and located using the location and numbering system used by the U.S. Bureau of Land Management. The system is illustrated in Figure 1. The first number denotes the township north of a base line, the second number denotes the range west of the fifth principal meridian, and the third number denotes the section in which the land tract is located. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarter section, quarter-quarter section, and quarter-quarter-quarter section (10-acre tract). For example, the land tract described by 150-062-04AD consists of 40 acres located in the SE 1/4 of the NE 1/4 of sec. 4, T. 150 N., R. 62 W.

INTERPRETATION OF RESULTS

While several classification schemes are used to describe soil suitability in this report, the key index rating soil irrigability is the Composite Soil Irrigability Index shown in Table 3. The index for evaluating water supply is the Water Availability Index shown in Table 4. These are shown for specific land tracts on Figures 2 and 3. A Combined Soil and Water Index rating both is shown on Figure 6. Composite Soil Index, Water Availability Index, and Combined Soil and Water Index are all listed for each tract in Appendix 1.

DETERMINING LOCAL SOIL SUITABILITY FOR IRRIGATION

In a previous report Olson and Schuh (1995) estimated acreage available for irrigation in twenty central North Dakota counties using soil association maps, estimates of sustainable yield, and estimates of the probability of obtaining water of suitable quality for irrigation. Acreage estimates of soils suitable for irrigation were based on North Dakota State University irrigability classifications (Omodt 1983). Soils classified as irrigable and conditionally irrigable vary in texture from coarse soils to loamy soils. They also include some soils that have special management limitations, such as slow soil drainage. Some conditionally irrigable soils are stony, and are only marginally suitable for tuber or root crop harvest. Others require special management of irrigation systems due to excessive slope, slow infiltration characteristics, or underlying impeding layers.

This evaluation was designed to apply a more restrictive soils criteria. Soils were screened on a series scale, and only soils classified as irrigable without restriction were included. Most soils were deep, well-drained, and highly permeable. A few were moderately well-drained, or

moderately permeable. None of the soils selected have persistent high water tables or tendencies to perch water for extended periods of time.

The soil evaluation was conducted on the basis of 40-acre tracts. All tracts considered were mapped predominantly (>50% of the mapped area) in soil series classified as irrigable without limitations. Each tract was classified in a two-step classification. First, they were classified by major texture group (sandy or loamy) . Second, they were grouped according to the amount and placement of soil series classified as conditionally irrigable within the tract. Specific limitations were then listed in coded form.

Classification by Texture Group:

Group I: Comprised of sandy soils classified as irrigable without limitations. These include:

(1) Arvilla sandy loam (0 to 6% slope) - deep, somewhat excessively drained, rapidly permeable soils. Shallow or moderately deep over sand and gravel.

(2) Binford sandy loam (0 to 6% slope) - similar to Arvilla, but having larger amount of shale particles.

(3) Claire loamy coarse sandy loam and loamy sand (0 to 6% slope) - deep, excessively drained soils that are very permeable in the upper profile, but have a slower permeability in the lower profile.

(4) Coe sandy loam (0 to 6% slope) - deep, excessively drained soils, with high permeability in upper and lower profiles. Parent materials have abundant shale particles.

(5) Egeland sandy loam (0 to 6% slope) - deep, well-drained sandy soils. Permeability is moderately rapid.

(6) Embden sandy loam (0 to 6% slope) - deep, moderately well-drained sandy soils on uplands.

(7) Emrick Sandy loam and loam - deep, moderately well-drained, moderately permeable soils on glacial uplands.

(8) Heimdal sandy loam (0 to 6% slope) - deep, well-drained, moderately permeable, sandy loam soil.

(9) Hecla loamy sand and sandy loam (0 to 8% slope) - deep, moderately well-drained, rapidly permeable soils on sandy uplands.

(10) Lohnes loamy coarse sand and sandy loam - deep, nearly level, moderately well-drained sandy soils. Permeability is rapid, and water-holding capacity is low.

(11) Maddock loamy sand and sandy loam (0 to 6% slope) - deep, well-drained, rapidly permeable soils on sandy uplands.

(12) Osakis sandy loam - shallow, nearly level, moderately well-drained soils. Permeability is moderately rapid in the upper profile to rapid in the lower profile.

(13) Swenoda fine sandy loams (0 to 6% slope) - deep, moderately well-drained, nearly level soils with moderately rapid permeability.

(14) Towner and Dickey fine sandy loams (0 to 6% slope) - deep, moderately well-drained soils.

(15) Walum sandy loam - moderately deep, moderately well-drained, nearly level soils that formed in modrerately coarse textured parent materials. Walum soils contain a high percentage of shale.

Group II: Comprised of loamy soils classified as irrigable without limitations. Soils in this group are usually deep and well-drained. Most are of lacustrine or fluvial-glacial rather than till origin, so they are not stony. Many are of silt loam texture. These include:

(1) Brantford loam (0 to 6% slope) - deep, well-drained loamy soil, that is shallow (one and a half to two feet) over shaley sand.

(2) Eckman loam (0 to 6% slope) - deep, well-drained, moderately permeable silt-loam soils.

(3) Fordville loam - deep, well-drained soils, that are moderately permeable in the upper part and rapidly permeable in the underlying material.

(4) Gardena loam - deep, moderately well-drained and moderately permeable silt-loam soil.

(5) Heimdal loam (0 to 6% slope) - deep, well-drained, moderately permeable, loamy soil.

(6) Kensal loam (0 to 6% slope) - moderately deep, nearly level, moderately well-drained soils. Permeability is rapid in the surface stratum and very rapid in the lower profile. The substratum is shalely.

(7) Renshaw loam (0 to 6% slope) - deep, somewhat excessively drained, rapidly permeable soils, shallow over sand and gravel.

(8) Vang loam - deep, well-drained soil of loamy texture, moderately deep over sand and gravel. Contains shale particles.

Other : Soils allowed as inclusions where local conditions indicate appropriate.

Serden sand - deep, nearly level to gently rolling, excessively drained soils. They have low water-holding capacity, low organic matter, and low fertility. Some may be suitable for irrigation without limitation.

Classification by Amount and Placement of Soil Mapping Units

All tracts considered had > 50% of their surface area mapped to a soil series classified as irrigable without limitations. These were then divided in two classes.

Class 1: Includes all 40-acre tracts mapped entirely to a soil series having no limitations for irrigation. No portion of a tract in this group is mapped to a soil series classified as having limitations or restrictions.

Class 2: Includes all 40-acre tracts mapped to a soil series listed above for more than half of its surface area. Some portion of the tract (less than half) is mapped in other series having potential management limitations for irrigation. The portion mapped to other series may be small, or it may approach as much as half the surface area.

For tracts having some soils with limitations, a Soil Limitation Area Index was devised to quantify the potential impairment for irrigation development. The Soil Limitation Area Index (shown Table 1 below) is based on the assumption that each tract is more suitable if a smaller portion of it is in less suitable soil classification, and that it is preferable to have the more limiting soil portions on the edge or border rather than in the interior of the tract.

Table 1.

Soil Limitation Area Index: Group 2	
INDEX	Area and Location of Limitation
1	Small area (< 25%) on border
2	small area (< 25%) within tract
3	large area (25 to 50%) on border
4	large area (25 to 50%) within tract

For each 40-acre tract the specific limitation of the less suitable series are listed using the labels in Table 2.

Table 2.

Soil Limitation Description Index	
LABEL	Nature of the Limitation
FS	Areas of fine soil
SF	Shallow fine layer - Fine subsoil at 2 to 4 feet
SG	Shallow gravel - within one foot of the surface
SL	Slope Greater than 6%
W	Wet (poorly drained) soil

To illustrate the use of this index, a 40-acre tract mapped almost entirely to a high suitability sandy soil series like the Hecla series, but having a slight amount of Hamar series (somewhat poorly drained) along the border would be indexed as W1. A tract of the same predominant series having a small amount of mapped series having > 6% slope in the interior of the tract would be indexed as SL2. A tract having a shallow clay layer, and a mapped surface area of > 25% but < 50% near the edge of the tract would be indexed as SF3. A tract having a minor, but fairly extensive (> 25% and < 50%) area of poorly drained soil within would be indexed as W4. These are listed for each set of tracts on Table 5.

Two additional attributes are assessed. It is often advantageous to have larger than 40-acre tracts for irrigation. If a designated 40-acre tract, or set of tracts can be combined with other tracts, either within the same section, or on an adjoining section, to form a single combined tract of 80 acres or more, it is labeled as Y, for yes. If the tract is isolated and combination with adjoining

tracts could result in a continuous tract of less than 80 acres, the designated tract is labeled as N, for no. The same assessment is made for 40-acre tracts that can be combined with other tracts to form a single combined tract of 160 acres or more. These are listed for each set of tracts on Table 5.

Composite Soil Irrigability Index

The two-tiered classification described above was used to provide detailed information concerning the amounts and types of soil limitations. These were further simplified to provide a quick visual (mapped) assessment of the tracts having best prospects for potential irrigation development.

The simplified Composite Soil Irrigability Index has three tiers. These are: (1) tracts having no mapped soil related limitations, (2) tracts having small mapped soil limitations along borders, and (3) tracts having somewhat larger mapped soil limitations, or limitations in the interior of the tracts. The Composite Soil Irrigability Index is summarized in Table 3. Locations of soils classified according to the Composite Soil Irrigability Index in Table 3 are shown on Figure 2, where tracts of index 1 are colored red, tracts of index 2 are colored green, and tracts of index 3 are colored yellow. Composite Soil Irrigability Indices are also listed in Appendix 1.

For sandy soils there are 165 40-acre tracts, or about 6,600 acres with an index of 1. There are 153 tracts, or about 6,120 additional acres, having an index of 2. There are 73 tracts, or about 2,920 additional acres having an index of 3. Soils having indices of 1 or 2 would have excellent prospects for irrigation development, with a suitable water supply. Soils having an index of 3 are less promising, but would still be worth considering as potential prospects for irrigation development, with a suitable water supply.

Table 3

Composite Soil Irrigability Index	
INDEX	Area and Location of Limitation
1	Group 1: tract has no limiting mapped soil units
2	Group 2: soil limitation index 1 from (Table 2)
3	Group 2: soil limitation index 2, 3, or 4 from (Table 2)

For loamy soils there were very few mixed soil series mapped. For this reason, and because there seems to be a current preference for irrigation on sandy soils, only tracts mapped

entirely to loamy soils having no irrigation limitations, or those having a combination of sandy and loamy soils, both having no irrigation restrictions were used. In Table 5, FI is used as a Soil Limitation Code. Tracts identified as having a Soil Limitation Code of FI are equivalent to a Composite Soil Irrigability Index of 1 in table 3, only for fine soils. There were 267 tracts, or about 10,680 acres of loamy soils having no irrigation restrictions.

In summary (all numbers rounded to the nearest 500 acres), there are about 17,000 acres in 40-acre tracts that are mapped predominantly to soil series suitable for irrigation without limitation. Of these about 6,500 are mapped entirely to sandy soils without limitation, and about 10,500 are mapped to loamy soils without restriction. About 6,000 are mapped to sandy soils having minor inclusions of soils with limitations on the borders of the tracts, and an additional 3,000 are mapped to sandy soils having larger inclusions of soils with irrigation limitations, or inclusions that are located in the interior of the tract. Limitation Classifications for each tract are listed in Table 5.

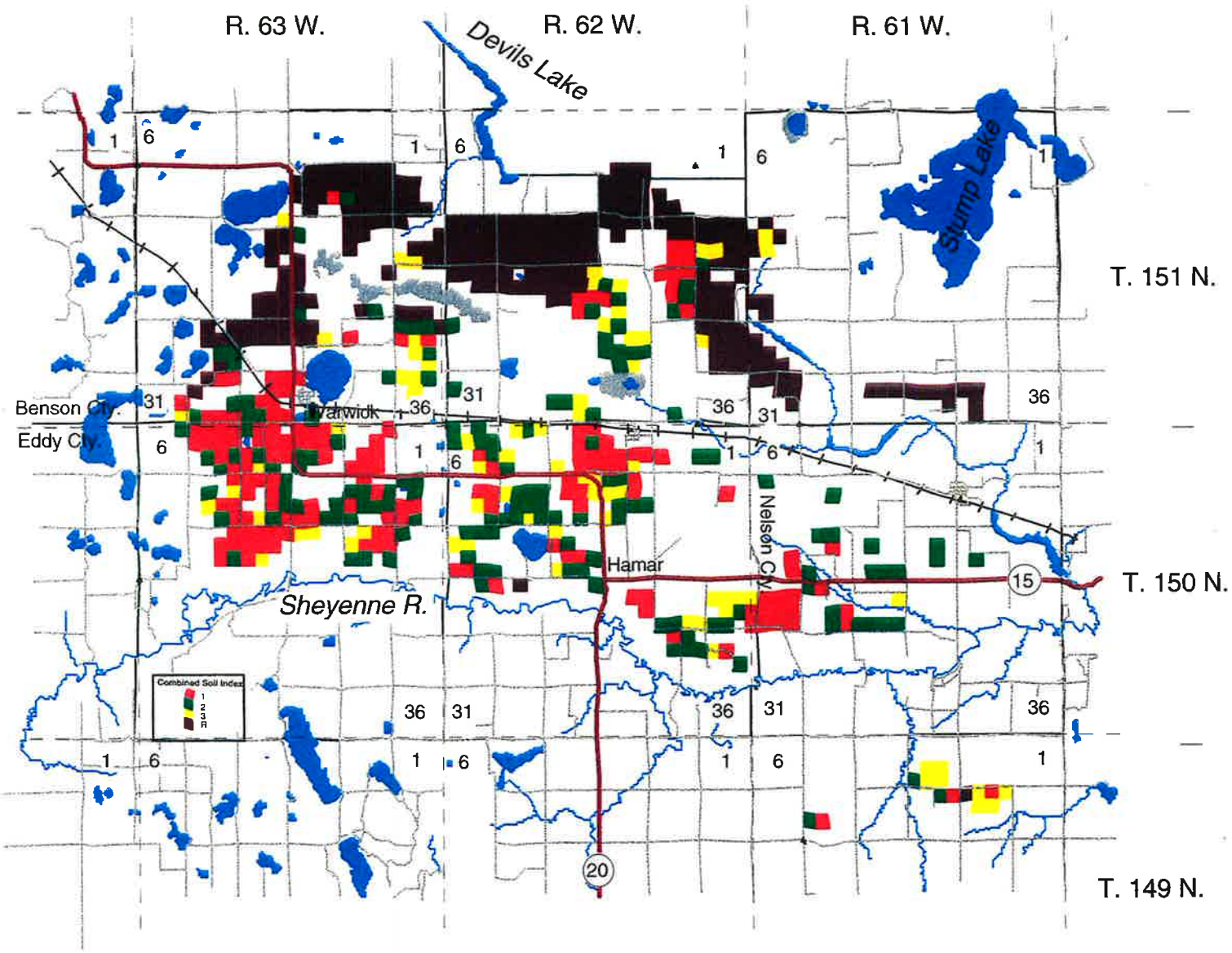

Figure 2. Map of soil irrigability, using the Composite Soil IrrigationSuitability Index from Table 3.

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

Table 4 Key

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
Township	Range	Section	1/4 Section	No. of 40-acre tracts with prime irrigable soil and without limits	Letter location of 40-acre tracts in N-1	No. of 40-acre tracts with prime irrigable soil and with some limits	Letter location of 40-acre tracts in N-2	Code designating soil limitations in N-2 tracts, as described on Table 2	Ability to form 80-acre tracts Y (Yes) or N (No)	Ability to form 160 -acre tracts Y (Yes) or N (No)

Table 4 continued for the next 7 pages

How to Use Table 4

Table 4 provides for each quarter section, the number and letter locations of 40-acre tracts having only prime irrigable soils, without limitations, and the number and letter locations of 40-acre tracts having predominantly prime irrigable soils, with some minor areas of soil having limitations. Table 4 also provides code descriptions of specific soil limitations, and an assessment of whether or not tracts in a quarter section can be combined to form combined land units of 80 acres or more.

An example of the use of Table 4 is as follows. The 7th entry from the top in Table 4 on page 11 is the northeast quarter of Township 149N, Range 61W, Section 10 (149-061-10A). **This entry is darkened in the table to aid in its location.** In this quarter section, one (1) 40-acre tract contains only soils mapped as irrigable without limitation (column N-1), and it is located in the northeast quarter of the northeast quarter section (letter A in column LOC-1). One (1) 40-acre tract contains mostly soils that are irrigable without limitation (column N-2). This tract is located in the northwest quarter section (letter B in column LOC-2). The soil limitations found in the minor inclusions are listed as FS1 (column Limitation Code). This code is taken from Tables 1 and 2, and indicates that the tract with soil limitations has the following limitation: some minor (less than 25% of the tract surface) inclusions of fine soil (FS from Table 2) located near the edge of the tract (1 from Table 1). The letter Y in the second to last column indicates that both of the single 40-acre tracts (AA and AB) can be combined with other tracts to form a tract 80 acres or more without major soil limitations. The letter N in the last column indicates that neither of the single 40-acre tracts (AA and AB) can be combined with other contiguous tracts, to form a combined land unit of 160 acres or more without major soil limitations.

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
149	61	2	D			1	C	FS1	Y	N
149	61	3	C			3	A	FS3	Y	Y
149	61	3	C				C	FS1	Y	Y
149	61	3	C				D	FS2	Y	Y
149	61	3	D			2	B	FS3	N	N
149	61	3	D				C	FS3	N	N
149	**61**	**10**	**A**	**1**	**A**				**Y**	**N**
						1	**B**	**FS1**	**Y**	**N**
149	61	11	A	1	B				Y	Y
						2	A	FS3	Y	Y
149	61	11	A				C	FS3	Y	Y
149	61	11	B			4	A	FS3	Y	Y
149	61	11	B				B	FI	Y	Y
149	61	11	B				C	FI	Y	Y
149	61	11	B				D	FS3	Y	Y
150	61	1	B	1	A				N	N
150	61	8	A			1	C	W1	N	N
150	61	14	C			1	A	W1	N	N
150	61	15	A			1	C	W1	N	N
150	61	15	D			1	B	W1	N	N
150	61	16	B			1	D	W1	N	N
150	61	16	C			1	D	W1	Y	N
150	61	16	D			2	C	W1	Y	N
150	61	16	D				D	W1	Y	N
150	61	17	A	1	C				Y	N
						1	B	W1	Y	N
150	61	17	B			1	A	W1	Y	N
150	61	17	C			1	C	W1	Y	N

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
150	61	18	C			1	D	W1	Y	N
150	61	18	D			2	A	W1	Y	N
150	61	18	D				D	W1	Y	N
150	61	19	A	2	CD				Y	Y
150	61	19	B	2	CD				Y	Y
150	61	19	C	4	ABCD				Y	Y
150	61	19	D	2	BC				Y	Y
						2	A	W1	Y	Y
150	61	19	D				D	W1	Y	Y
150	61	20	B	1	A				Y	N
						1	B	SL1	Y	N
150	61	20	D	2	AD				Y	Y
						2	B	FS1	Y	Y
150	61	20	D				C	FS1	Y	Y
150	61	21	A			1	D	W3	Y	N
150	61	21	C			2	C	W1, FS1	Y	N
150	61	21	C				D	W1, FS1	Y	N
150	61	21	D			2	C	W1, FS1	Y	N
150	61	21	D				D	W1, FS1	Y	N
150	62	1	C			2	A	W1	Y	N
150	62	1	C				B	W1	Y	N
150	62	3	B	1	C				Y	Y
150	62	3	C	4	ABCD				Y	Y
150	62	3	D	2	AB				Y	N
						1	C	FS4	Y	N
150	62	4	A	3	ABC				Y	Y
						1	D	W1	Y	Y
150	62	4	C			2	C	W4, SL4 *	Y	Y
150	62	4	C				D	W4, SL4	Y	Y
150	62	4	D	4	ABCD				Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
150	62	5	A			2	A	W3	Y	Y
150	62	5	A				B	W1	Y	Y
150	62	5	B			1	A	W2	N	N
150	62	5	C			2	B	W4	Y	N
150	62	5	C				C	W1	Y	N
150	62	6	A			3	B	W1	Y	N
150	62	6	A				C	W2	Y	Y
150	62	6	A				D	W1	Y	Y
150	62	6	B			3	B	W1	Y	N
150	62	6	B				C	W1	Y	N
150	62	6	B				D	W2	Y	N
150	62	6	D	2	BD					
						2	A	W1	Y	Y
150	62	6	D				C	W3	Y	Y
150	62	7	A	2	CD				Y	Y
150	62	7	D	1	A				Y	Y
						2	B	W4	Y	Y
150	62	7	D				D	W1	Y	Y
150	62	8	A			2	C	W1	Y	Y
150	62	8	A				D	W1	Y	Y
150	62	8	B			2	C	W4	Y	Y
150	62	8	B				D	W1	Y	Y
150	62	8	C			3	A	W1	Y	N
150	62	8	C				C	W1	Y	N
150	62	8	C				D	W1	Y	N
150	62	8	D			4	A	W1	Y	Y
150	62	8	D				B	W1	Y	Y
150	62	8	D				C	W3	Y	Y
150	62	8	D				D	W1	Y	Y
150	62	9	A	1	C				Y	Y
						3	A	ROAD	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
150	62	9	A				B	ROAD	Y	Y
150	62	9	A				D	ROAD	Y	Y
150	62	9	B	2	AD				Y	Y
150	62	9	C			1	C	W1	N	N
150	62	9	D	1	B				Y	N
						1	C	W1	Y	N
150	62	10	A	2	BC				Y	Y
150	62	10	B			4	A	W1	Y	Y
150	62	10	B				B	W1	Y	Y
150	62	10	B				C	W4	Y	Y
150	62	10	B				D	W4	Y	Y
150	62	10	C			3	A	W1	Y	N
150	62	10	C				C	W1	Y	N
150	62	10	C				D	W1	Y	N
150	62	10	D			2	A	W1	Y	N
150	62	10	D				B	W1	Y	N
150	62	12	B	1	D				N	N
150	62	16	B	1	C				Y	Y
						2	B	W4	Y	Y
150	62	16	B				D	W1	Y	Y
150	62	16	C	1	A				Y	Y
						3	B	W3	Y	Y
150	62	16	C				C	W3	Y	Y
150	62	16	C				D	W1	Y	Y
150	62	16	D	1	B				Y	Y
						3	A	W1	Y	Y
150	62	16	D				C	W1	Y	Y
150	62	16	D				D	W3	Y	N
150	62	18	A			2	A	W1	Y	N
150	62	18	A				B	W1	Y	N
150	62	18	B			4	A	W1	Y	N
150	62	18	B				B	W4	Y	N
150	62	18	B				C	W1	Y	N

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
150	62	18	B				D	W3	Y	N
150	62	18	C	2	C				Y	Y
						1	A	W1	Y	Y
150	62	18	D		D				Y	Y
						2	C	W1	Y	Y
150	62	18	D				D	W1	Y	Y
150	62	19	A			2	A	W1	Y	Y
150	62	19	A				B	W1	Y	Y
150	62	20	B	1	B				Y	N
						1	A	W4	Y	N
150	62	21	A			1	A	W1	Y	N
150	62	22	A	2	CD				Y	N
150	62	22	B			1	B	W1	Y	N
150	62	22	D	1	A				Y	N
150	62	23	C			2	C	W1	Y	N
150	62	23	C				D	W1	Y	N
150	62	23	D			2	C	W4	Y	N
150	62	23	D				D?	W4	Y	N
150	62	24	A			2	C	W3	Y	N
150	62	24	A				D	W3	Y	N
150	62	24	B			2	C	W3	Y	N
150	62	24	B				D	W3	Y	N
150	62	24	C			3	A	W3	Y	N
150	62	24	C				C	W1	Y	N
150	62	24	C				D	W1	Y	N
150	62	24	D	2	AD				Y	N
						1	B	FS3	Y	N
150	62	25	B	1	D				Y	N
						1	C	W3	Y	N

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
150	62	25	D			1	B	W1	N	N
150	62	26	A			3	B	W1	Y	Y
150	62	26	A				C	W1	Y	Y
150	62	26	A				D	W1	Y	Y
150	62	26	B	1	A				Y	Y
						1	D	W1	Y	Y
150	63	2	A	2	AC				Y	N
150	63	3	A	3	ABC				Y	Y
						1	D	W1	Y	Y
150	63	3	B	4	ABCD				Y	Y
150	63	3	C			4	A	W1	Y	Y
150	63	3	C				B	W1	Y	Y
150	63	3	C				C	W1	Y	N
150	63	3	D	1	B				Y	Y
150	63	4	A	3	BCD				Y	Y
150	63	4	B	2	AB				Y	Y
150	63	4	C	3	ABC				Y	Y
						1	D	W1	Y	Y
150	63	5	A	4	ABCD				Y	Y
150	63	5	B	4	ABCD				Y	Y
150	63	5	C			1	A	W1	Y	Y
150	63	5	D	2	BD				Y	Y
						2	A	W1	Y	Y
150	63	5	D				C	W1	Y	Y
150	63	6	A			1	A	W1	N	N
150	63	8	A	1	A				Y	Y
						1	D	W1	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
150	63	8	B	1	D				Y	N
150	63	8	C			1	W	W3	Y	N
150	63	8	D	2	AB				Y	N
						2	C	W1, SL1	Y	N
150	63	8	D				D	W1, SL1	Y	N
150	63	9	A	2	BC				Y	Y
						2	A	W1, SL1	Y	Y
150	63	9	B	3	ABC				Y	Y
150	63	9	C	1	C				Y	N
						1	D	W1, SL1	Y	N
150	63	9	D	2	BD				Y	Y
						2	A	W1	Y	Y
150	63	9	D				C	W1	Y	Y
150	63	10	C	3	ACD				Y	Y
						1	B	W1	Y	Y
150	63	10	D			3	A	W1	Y	Y
150	63	10	D				C	W1	Y	Y
150	63	10	D				D	W1	Y	Y
150	63	11	A	1	C	1	D	W1	Y	N
150	63	11	B	1	A				Y	Y
						2	C	W1,SL1	Y	Y
150	63	11	B				D	W1, SL1	Y	Y
150	63	11	C	1	B				Y	N
						2	A	W1	Y	N
150	63	11	C				C	W1	Y	N
150	63	11	D	2	AD				Y	Y
						1	B	W1	Y	Y
150	63	12	B			3	A	W1	Y	N
150	63	12	B				B	W1	Y	N
150	63	12	B				D	W1	Y	N
150	63	12	C	3	ABC				Y	Y
						1	D	W3, SL3	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
150	63	13	B	1	B				Y	N
150	63	14	A	4	ABCD				Y	Y
150	63	14	B	1	D				Y	Y
150	63	14	B			3	A	SL1	Y	Y
150	63	14	B				B	SL3	Y	Y
150	63	14	B				C	SL4	Y	Y
150	63	14	C			2	A	SL2	Y	Y
150	63	14	C				B	SL2	Y	Y
150	63	15	B			2	A	SL2	Y	Y
150	63	15	B				B	SL3	Y	Y
150	63	16	A	3	ABC				Y	Y
						1	D	SL4	Y	Y
150	63	16	B	4	ABCD				Y	Y
150	63	16	C	1	B				Y	Y
						1	A	SL1, W1	Y	Y
150	63	17	A	3	ACD				Y	Y
150	63	17	D	1	B				Y	N
						1	A	W1,SL1	Y	N
151	61	18	A			1	C	F1	Y	N
151	61	18	B			3	A	SL1	Y	N
151	61	18	B				C	FI	Y	Y
151	61	18	B				D	FI	Y	Y
151	61	18	C			2	A	FS1, SL1	Y	Y
151	61	18	C				B	FI, SL1	Y	Y
151	61	19	C			3	A	FI	Y	N
151	61	19	C				B	FI, SL1	Y	N
151	61	19	C				D	FI, W1	Y	N

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	61	30	B			1	C	FI	Y	Y
151	61	30	C			4	A	FI	Y	Y
151	61	30	C				B	FI	Y	Y
151	61	30	C				C	FI	Y	Y
151	61	30	C				D	FI	Y	Y
151	61	30	D			1	C	FI	Y	Y
151	61	31	A			4	A	FI, FS1	Y	Y
151	61	31	A				B	FI	Y	Y
151	61	31	A				C	FI	Y	Y
151	61	31	A				D	FI	Y	Y
151	61	31	B			2	A	FI	Y	Y
151	61	31	B				B	FI	Y	N
151	61	31	D			1	D	FI	Y	N
151	61	33	A			2	C	FI	Y	N
151	61	33	A				D	FI	Y	N
151	61	33	B			1	D	FI	Y	N
151	61	34	A			2	C	FI	Y	N
151	61	34	A				D	FI	Y	N
151	61	34	B			2	C	FI	Y	N
151	61	34	B				D	FI	Y	N
151	61	34	D			1	A	FI, W1	Y	N
151	61	35	B			2	C	FI	Y	N
151	61	35	B				D	FI	Y	N
151	61	35	C			2	A	FI	Y	N
151	61	35	C				D	FI	Y	N
151	62	10	A			A	A	FI	Y	Y
151	62	10	A				B	FI	Y	Y
151	62	10	A				C	FI	Y	Y
151	62	10	A				D	FI	Y	Y
151	62	10	B			3	A	FI	Y	Y
151	62	10	B				C	FI	Y	Y
151	62	10	B				D	FI	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	62	10	C			4	A	FI	Y	Y
151	62	10	C				B	FI	Y	Y
151	62	10	C				C	FI	Y	Y
151	62	10	C				D	FI	Y	Y
151	62	10	D			4	A	FI	Y	Y
151	62	10	D				B	FI	Y	Y
151	62	10	D				C	FI	Y	Y
151	62	10	D				D	FI	Y	Y
151	62	11	B			3	B	FI	Y	Y
151	62	11	B				C	FI	Y	Y
151	62	11	B				D	FI	Y	Y
151	62	11	C			4	A	FI	Y	Y
151	62	11	C				B	FI	Y	Y
151	62	11	C				C	FI	Y	Y
151	62	11	C				D	FI	Y	Y
151	62	11	D			1	C	FI, W1	Y	N
151	62	13	A			4	A	FI, FS1, W1	Y	Y
151	62	13	A				B	FI, FS1, W1	Y	Y
151	62	13	A				C	FI, FS1, W1	Y	Y
151	62	13	A				D	FI, FS1, W1	Y	Y
151	62	13	B			4	A	FI	Y	Y
151	62	13	B				B	FI	Y	Y
151	62	13	B				C	FI	Y	Y
151	62	13	B				D	FI	Y	Y
151	62	13	C			4	A	FS3, W2	Y	Y
151	62	13	C				B	FS1	Y	Y
151	62	13	C				C	FS1	Y	Y
151	62	13	C				D	FS1	Y	Y
151	62	13	D			4	A	FI	Y	Y
151	62	13	D				B	FI	Y	Y
151	62	13	D				C	FI	Y	Y
151	62	13	D				D	FI	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	63	11	B				D	FI	Y	Y
151	63	11	C			4	A	FI	Y	Y
151	63	11	C				B	FS1	Y	Y
151	63	11	C				C	FI	Y	Y
151	63	11	C				D	FI	Y	Y
151	63	11	D			4	A	FI	Y	Y
151	63	11	D				B	FI	Y	Y
151	63	11	D				C	FI	Y	Y
151	63	11	D				D	FI	Y	Y
151	63	12	B			2	C	FI	Y	Y
151	63	12	B				D	FS3, W3	Y	Y
151	63	12	C			4	A	FI	Y	Y
151	63	12	C				B	FI	Y	Y
151	63	12	C				C	FI	Y	Y
151	63	12	C				D	FI	Y	Y
151	63	12	D			1	C	FI, SL2	Y	N
151	63	13	A			1	D	FI	Y	Y
151	63	13	B			1	B	FI	N	N
151	63	13	C			3	A	FI	Y	Y
151	63	13	C				C	LS1	Y	Y
151	63	13	C				D	LS1	Y	Y
151	63	13	D			4	A	FI	Y	Y
151	63	13	D				B	FI	Y	Y
151	63	13	D				C	FI	Y	Y
151	63	13	D				D	FI	Y	Y
151	63	14	A			3	A	FI	Y	N
151	63	14	A				B	FI	Y	N
151	63	14	A				D	FI, FS1	Y	N
151	63	14	B			4	A	FI	Y	Y
151	63	14	B				B	FI	Y	Y
151	63	14	B				C	FI	Y	Y
151	63	14	B				D	FI	Y	Y
151	63	14	C			1	B	FI	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	62	14	A			4	A	FI	Y	Y
151	62	14	A				B	FI	Y	Y
151	62	14	A				C	FI	Y	Y
151	62	14	A				D	FI	Y	Y
151	62	14	B			2	A	FS1, W1	Y	N
151	62	14	B				B	FS1, W1	Y	N
151	62	14	D	4	ABCD				Y	Y
151	62	15	A			2	A	FI	Y	Y
151	62	15	A				B	FI	Y	Y
151	62	15	B			3	A	FI	Y	N
151	62	15	B				B	FI, W1	Y	N
151	62	15	B				D	FI, W1	Y	N
151	62	16	A			4	A	FI, W1	Y	Y
151	62	16	A				B	FI, W1	Y	Y
151	62	16	A				C	FI, W1	Y	Y
151	62	16	A				D	FI, W1	Y	Y
151	62	16	B			4	A	FI, W1	Y	Y
151	62	16	B				B	FI, W1	Y	Y
151	62	16	B				C	FI, W1	Y	Y
151	62	16	B				D	FI, W1	Y	Y
151	62	16	C			4	A	FI	Y	Y
151	62	16	C				B	FI	Y	Y
151	62	16	C				C	FI	Y	Y
151	62	16	C				D	FI	Y	Y
151	62	16	D			4	A	FI, W1	Y	Y
151	62	16	D				B	FI	Y	Y
151	62	16	D				C	FI	Y	Y
151	62	16	D				D	FI	Y	Y
151	62	17	A			4	A	FI, W1	Y	Y
151	62	17	A				B	FI	Y	Y
151	62	17	A				C	FI	Y	Y
151	62	17	A				D	FI	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	62	17	B			4	A	FI	Y	Y
151	62	17	B				B	FI	Y	Y
151	62	17	B				C	FI	Y	Y
151	62	17	B				D	FI	Y	Y
151	62	17	C			4	A	FI	Y	Y
151	62	17	C				B	FI	Y	Y
151	62	17	C				C	FI	Y	Y
151	62	17	C				D	FI	Y	Y
151	62	17	D			4	A	FI	Y	Y
151	62	17	D				B	FI	Y	Y
151	62	17	D				C	FI	Y	Y
151	62	17	D				D	FI	Y	Y
151	62	18	A			4	A	FI	Y	Y
151	62	18	A				B	FI	Y	Y
151	62	18	A				C	FI	Y	Y
151	62	18	A				D	FI	Y	Y
151	62	18	B			4	A	FI	Y	Y
151	62	18	B				B	FI	Y	Y
151	62	18	B				C	FI	Y	Y
151	62	18	B				D	FI	Y	Y
151	62	18	C			4	A	FI	Y	Y
151	62	18	C				B	FI	Y	Y
151	62	18	C				C	FI	Y	Y
151	62	18	C				D	FI	Y	Y
151	62	18	D			4	A	FI	Y	Y
151	62	18	D				B	FI	Y	Y
151	62	18	D				C	FI	Y	Y
151	62	18	D				D	FI	Y	Y
151	62	19	A			4	A	FI	Y	Y
151	62	19	A				B	FI	Y	Y
151	62	19	A				C	FI	Y	Y
151	62	19	A				D	FI	Y	Y
151	62	19	B			4	A	FI	Y	Y
151	62	19	B				B	FI	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	62	20	A			4	A	FI	Y	Y
151	62	20	A				B	FI, SL1	Y	Y
151	62	20	A				C	FI, SL1	Y	Y
151	62	20	A				D	FI, SL1	Y	Y
151	62	20	B			4	B	FI	Y	Y
151	62	20	B				C	FI	Y	Y
151	62	20	B				D	FI, SL1	Y	Y
151	62	21	A			4	A	FS4	Y	Y
151	62	21	A				B	SL4	Y	Y
151	62	21	A				C	FI	Y	Y
151	62	21	A				D	FI	Y	Y
151	62	21	B			4	A	FI	Y	Y
151	62	21	B				B	FI	Y	Y
151	62	21	B				C	FI	Y	Y
151	62	21	B				D	FI	Y	Y
151	62	21	C			4	A	FI	Y	Y
151	62	21	C				B	FI	Y	Y
151	62	21	D	3	ABC				Y	Y
						1	D	W1, FS1	Y	Y
151	62	22	B			2	C	W1	Y	Y
151	62	22	B				D	W4	Y	Y
151	62	22	C	1	B				Y	Y
						2	A	W1	Y	Y
151	62	22	C				D	W4	Y	Y
151	62	23	A	3	ABC				Y	Y
						1	D	FS1	Y	Y
151	62	23	B	1	A				Y	N
151	62	23	D	2	BD				Y	Y
						2	A	FS1?	Y	Y
151	62	23	D				C	FS1?	Y	Y
151	62	24	A			2	A	SL1	Y	Y
151	62	24	A				C	SL1	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	62	24	B			3	B	FI	Y	Y
151	62	24	B				C	FI	Y	Y
151	62	24	B				D	FI	Y	N
151	62	24	C			4	A	FI	Y	Y
151	62	24	C				B	FI, W1	Y	N
151	62	24	C				C	FI, W4	Y	N
151	62	24	C				D	FI	Y	Y
151	62	24	D			2	B	FI	Y	Y
151	62	24	D				C	FI	Y	Y
151	62	25	A			4	A	FI, SL1	Y	Y
151	62	25	A				B	FI	Y	Y
151	62	25	A				C	FI	Y	Y
151	62	25	A				D	FI	Y	Y
151	62	25	B			4	A	FI	Y	Y
151	62	25	B				B	FI	Y	Y
151	62	25	B				C	FI, W1	Y	Y
151	62	25	B				D	FI	Y	Y
151	62	25	C			2	C	FI	Y	Y
151	62	25	C				D	FI	Y	Y
151	62	25	D			4	A	FI	Y	Y
151	62	25	D				B	FI	Y	Y
151	62	25	D				C	FI	Y	Y
151	62	25	D				D	FI	Y	Y
151	62	27	A			2	C	W4	Y	Y
151	62	27	A				D	W3	Y	Y
151	62	27	B			3	A	W1	Y	Y
151	62	27	B				B	W1	Y	Y
151	62	27	B				C	W1	Y	Y
151	62	27	C				A	W1	Y	Y
151	62	27	C			3	C	W1	Y	Y
151	62	27	C				D	W1	Y	Y
151	62	27	D			3	A	W1	Y	Y
151	62	27	D				B	W1	Y	Y
151	62	27	D				C	W1	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	62	30	B			1	B	FS1	Y	N
151	62	31	B			1	C	FS1	N	N
151	62	33	C			2	A	W1	Y	N
151	62	33	C				B	W1	Y	N
151	62	33	D			3	B	W2	Y	N
151	62	33	D				C	W4	Y	N
151	62	33	D			1	D	W1	Y	N
151	62	35	C			1	D	W1	N	N
151	63	10	A			4	A	SG2, FI	Y	Y
151	63	10	A				B	FI, SLF, SG2	Y	Y
151	63	10	A				C	FI	Y	Y
151	63	10	A				D	FI	Y	Y
151	63	10	B			1	A	FI, SL2	Y	Y
151	63	10	C			3	A	FI, SL3	Y	N
151	63	10	C				B	FI	Y	N
151	63	10	C				D	W1	Y	N
151	63	10	D	1	A				Y	Y
						1	B	W1	Y	Y
151	63	11	A			4	A	FI, W1	Y	Y
151	63	11	A				B	FI	Y	Y
151	63	11	A				C	FI	Y	Y
151	63	11	A				D	FI	Y	Y
151	63	11	B			4	A	FI	Y	Y
151	63	11	B				B	FI	Y	Y
151	63	11	B				C	FI	Y	Y
151	63	15	B			1	C	FS1	N	N
151	63	15	C			1	C	FI, SL1	N	N
151	63	16	A			3	A	FS1	N	N
151	63	16	D				C	FI	Y	Y
151	63	16	D				D	FI	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	63	16	D			3	A	FI	Y	Y
151	63	16	D				B	FI	Y	Y
151	63	16	D				C	FI	Y	Y
151	63	21	A			2	A	FI, FS1	Y	N
151	63	21	A				D	FI	Y	N
151	63	21	C			1	D	FI, W1	Y	Y
151	63	21	D			4	A	FI	Y	Y
151	63	21	D				B	FI, FS2	Y	Y
151	63	21	D				C	FI	Y	Y
151	63	21	D				D	FI, FS2	Y	Y
151	63	22	B			2	B	FI, W1	Y	N
151	63	22	B				C	FI	Y	N
151	63	22	C				A	FI, W1	Y	N
151	63	22	C			2	B	FI	Y	Y
151	63	22	C				C	FI, FS1	Y	Y
151	63	23	A			1	A	FI	N	N
151	63	23	C			2	C	FS1	Y	N
151	63	23	C				D	FI, FS1	Y	N
151	63	23	D			2	C	FS1	Y	N
151	63	23	D				D	FI	Y	Y
151	63	24	C			2	C	FI	Y	Y
151	63	24	C				D	FS1	Y	Y
151	63	24	D			1	C	FI, FS1	Y	Y
151	63	25	A	1	C				Y	Y
						2	A	FS3	Y	Y
151	63	25	A				B	FS1	Y	Y
151	63	25	B	1	C				Y	Y
						3	A	FS1	Y	Y
151	63	25	B				B	W1	Y	Y
151	63	25	B				D	W2	Y	Y
151	63	25	C			1	A	W1	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	63	25	D	1	B				Y	Y
						2	A	FS4	Y	Y
151	63	25	D				C	W1	Y	Y
151	63	25	D							
151	63	26	B				C	W1	Y	N
151	63	27	A			2	C	W2	Y	N
151	63	27	A				D	W2	Y	N
151	63	27	B			4	A	FI, W1	Y	Y
151	63	27	B				B	FI, W1	Y	Y
151	63	27	B				C	FI, W1	Y	Y
151	63	27	B				D	W2	Y	Y
151	63	27	C			2	B	W1	Y	N
151	63	27	C				C	W1	Y	
151	63	28	A			4	A	FI	Y	Y
151	63	28	A				B	FI	Y	Y
151	63	28	A				C	FI	Y	Y
151	63	28	A				D	FI	Y	Y
151	63	28	B			4	A	FI	Y	Y
151	63	28	B				B	FI	Y	Y
151	63	28	B				C	FI	Y	Y
151	63	28	B				D	FI	Y	Y
151	63	29	A			4	A	FI	Y	Y
151	63	29	A				B	RR TRACK	Y	Y
151	63	29	A				C	RR TRACK	Y	Y
151	63	29	A				D	FI	Y	Y
151	63	29	B			2	A	FI	Y	Y
151	63	29	B				D	FO	Y	Y
151	63	29	D			4	A	FS1	Y	Y
151	63	29	D				B	FS1	Y	Y
151	63	29	D				C	FS2	Y	Y
151	63	29	D				D	FI	Y	Y

Table 4. Township (T), Range (R), Section (S), quarter section (1/4 S), number of 40-acre tracts in the quarter section having prime irrigable soil (N-1), letter location of N-1 tracts (LOC-1), number of 40-acre tracts having some minor limitation (N-2), letter location of N-2 tracts, Limitation Code describing soil limitations in N-2 tracts, as described on Table 2, and index indicating the ability to combine with neighboring 40-acre tracts to form a minimum unit of 80 contiguous acres (I-80) and 160 contiguous acres (I-160).

T	R	S	1/4 S	N-1	LOC-1 1/4, 1/4 S 40-acre tracts	N-2	LOC-2 1/4, 1/4 S 40-acre tracts	Limitation Code	I-80	I-160
151	63	31	D	1	D	1	A	W1	Y	Y
151	63	32	A	2	AB				Y	N
151	63	32	B			2	A	FS1	Y	N
151	63	32	B				C	FS1	Y	N
151	63	32	C	1	D				Y	Y
						1	C		Y	Y
151	63	32	D	2	CD				Y	Y
						1	A	FS1	Y	Y
151	63	33	A	3	BCD				Y	Y
						1	A	W1	Y	Y
151	63	33	C	4	ABCD				Y	Y
151	63	33	D	2	CD				Y	N
151	63	34	B	1	B				N	N
151	63	34	C			1	D	FS1	N	N
151	63	35	A			1	B	W1	Y	N
151	63	36	A							
151	63	36	B			2	B	W1	Y	N
151	63	36	D				D	W1	Y	N

DETERMINING LOCAL GROUND-WATER AVAILABILITY FOR IRRIGATION

In addition to soil suitable for irrigation, land tracts must have a nearby source of water. Potential ground-water sources for the selected tracts are in the Warwick aquifer and the Spiritwood aquifer.

Local Water Supplies in the Spiritwood and Warwick Aquifers

The Spiritwood aquifer underlies about 52 square miles in Nelson County, and extends into Eddy, Benson, and Nelson counties (Downey 1973). Randich (1977) described a segment of the Spiritwood aquifer, labeled the "Spiritwood aquifer system near Warwick," as a segment of the aquifer that occurs in a "buried valley that underlies about 12 mi^2 of the Warwick aquifer in southeastern Benson county" and extends north beneath an "east-trending end moraine and Devils Lake." Trapp (1968) reported that the extent of the Spiritwood aquifer was unknown in eastern Eddy county. He reported saturated thicknesses ranging from 16 feet to 67 feet. Randich reported that in Benson county the top of the aquifer was about 79 to 180 feet below land surface, and the aquifer had an average thickness of about 94 feet. In Nelson County, it has a "maximum thickness of about 320 feet, with an average thickness of about 100 feet, consisting of interbedded clay, silt, sand, and gravel." Yields greater than 500 gpm are possible near the center of the aquifer, but in thinner peripheral parts may be considerably less (Downey 1973) . Randich estimated potential yields as from 250 gpm to 1,500 gpm in Benson county.

The Warwick aquifer has been described as composed of glacial outwash deposits extending from the North Viking moraine in Benson and Ramsey counties to the Sheyenne River in Eddy and Nelson counties (Randich 1977). Northeast of Warwick it overlies part of the Spiritwood aquifer system. The Warwick underlies about 30 mi^2 of eastern Benson County (Randich 1977) and extends southward to the top half of T. 150, R. 62 and 63 in Eddy County (Trapp 1968). Saturated thickness in Benson county has been reported as ranging from 20 to 200 feet with an average of 73 feet. Potential yields have been reported at 50 to 500 gpm, with possible yields as high as 1,500 gpm (Randich 1973).

For each of the 40-acre land tracts evaluated in this report, potential water availability was assessed using two criteria, as determined from the maps of Downey (1973), Randich (1977), and Trapp (1968). These criteria were pumpability, and extensiveness. Pumpability categories were (1) 50 to 500 gpm, and (2) 500 to 1,500 gpm. Extensiveness categories were (1) aquifer mapped as occupying more than 50% of the section containing the designated 40-acre tract (broad area) , and (2) aquifer mapped as occupying less than 50% of the section containing the designated 40-acre tract (limited area). The extensiveness of the mapped aquifer area underlying the tract is weighted slightly more strongly than the pumping rate, because a more extensive aquifer gives a higher probability of finding water of suitable quality for irrigation, and somewhat slower pumping

rates can be offset by multiple wells, if aquifer area is sufficient. The index derived for water availability is scaled from 1 to 4 as shown on Table 5 below. The lowest of the Water Availability Index numbers indicate the highest probability of finding the amount of water of quality suitable required for irrigation of the designated 40-acre tract in the section on which the tract is located.

A map of tracts according to the Water Availability Index is shown on Figure 3. The likelihood of finding a suitable water supply is indicated by red for Water Availability Index 1 (Table 4), green for Water Availability Index 2, and yellow for Index 4 (no Indices of 3 were found). Water availability indices for each tract are listed in Appendix 1.

Table 5.

Water Availability Index	
INDEX	Area and Location of Limitation
1	500 to 1,500 gpm, broad area
2	50 to 500 gpm, broad area
3	500 to 1,500 gpm, limited area
4.	50 to 500 gpm, limited area

About 271 forty-acre tracts, or 10,840 acres likely overlay aquifers having broad local area coverage and high pumpage. Another 208 tracts, or 8,320 acres overlay aquifers having more limited pumpage, but broad areal extent. Ninety-one additional tracts, or about 3,640 acres, were located in sections having some possible water supplies, but where either low potential pumpage, or low aquifer extent might limit water availability. Local water would thus likely be available for irrigation of about 18,500 acres, under the designated tracts. Water quality for most of these sites should be adequate for irrigation.

Water Quality

Water that is highly saline or sodic, or that contains excessive boron is unsuitable for irrigation. High sodium in irrigation water destroys soil structure and causes crusting. Eventually accumulated sodium can reach levels that are toxic to many crops. High salt content in irrigation water, as indicated by a high electrical conductivity, can cause accumulation and concentration of salts in the soil, eventually impeding root uptake of water and nutrients and decreasing yields. Even with reasonably good irrigation water, salts must be periodically leached from the soil zone to prevent buildup.

Water quality in this segment of the Spiritwood aquifer varies, but is generally suitable for irrigation. For Nelson County, Downey (1973) reported dissolved solids in eighteen samples ranging from about 300 to 1,000 mg/L, and with a mean of about 660 mg/l. The water was

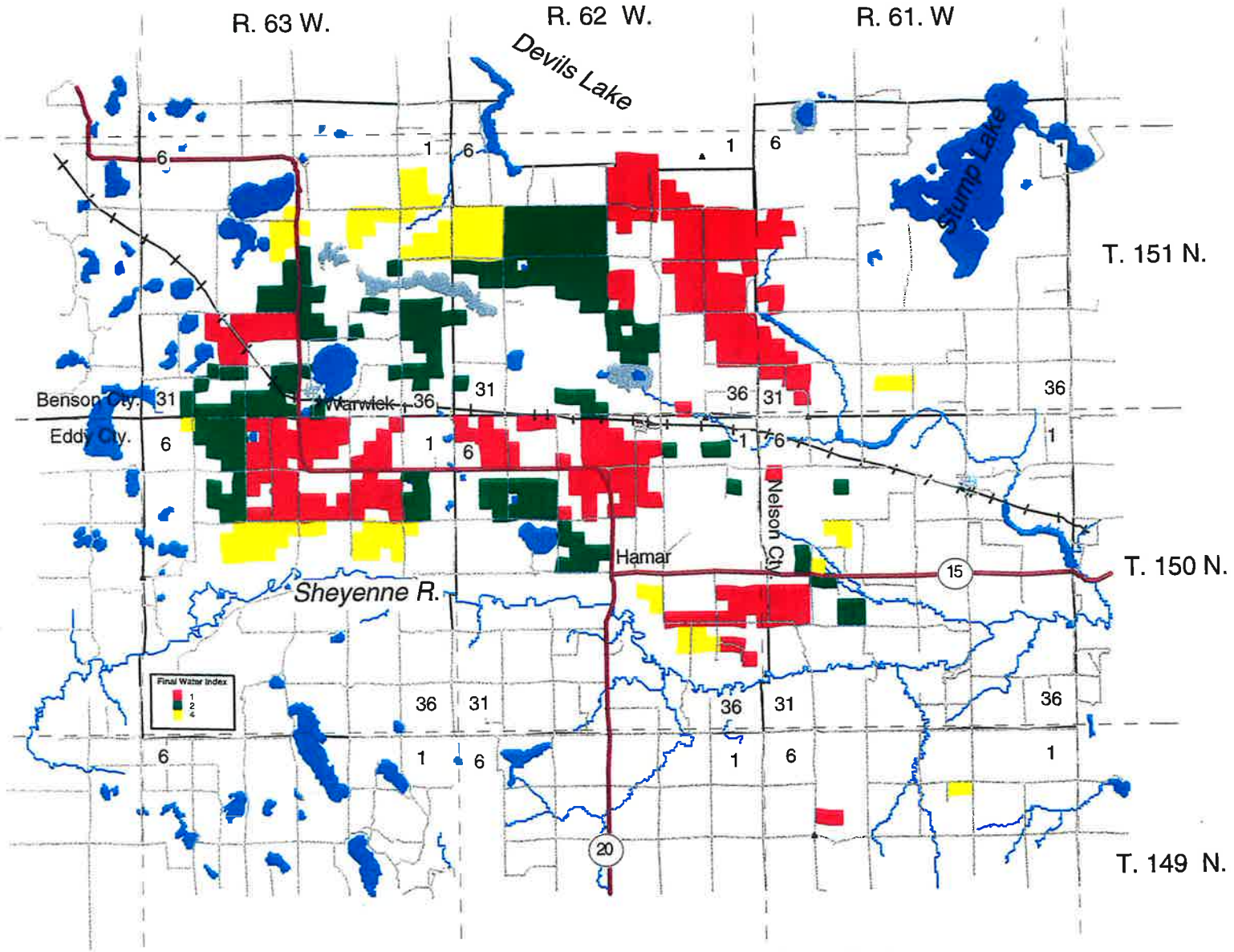

Figure 3. Map of water availability, using the Water Availability Index fromTable 4.

reported to be predominantly of the calcium and sodium bicarbonate type, but in some areas it may be of the sodium sulfate type. Trapp (1968) reported that dissolved solids for one water sample taken in Eddy county contained 832 mg/L dissolved solids. Dissolved solids in six water samples from Benson county ranged from 300 to 1000 mg/L, with an average of 464 mg/L (Randich, 1977). Water was predominantly of the calcium bicarbonate type. A survey of water samples from 83 wells, including recent samples, indicate that the entire range of electrical conductivities (377 to 1,650 microsiemens per cm (μS/cm) is suitable for irrigation use on soils classified as irrigable without limitation (Figure 2), although the maximum value may be somewhat marginal for some fine and conditionally irrigable soils. Similarly, the range of SAR values (0.1 to 8) is suitable for unconditionally irrigable soils, but the upper part of the range may be problematic on some conditionally irrigable soils. A more conservative upward limit of 1,500 μS/cm and SAR = 6 used for some of our previous assessment studies were met by all Warwick aquifer samples, and for more than 85% of the Spiritwood samples.

Randich (1973) reported that the water chemistry of the Warwick aquifer is of the calcium bicarbonate type. Dissolved solids were reported to range from 200 to 1,000 mg/L, with a mean of less than 300 mg/L. A current survey of 35 wells in the Warwick aquifer, indicates that the entire range of sodium adsorption ratios (0.1 to 3) is suitable for irrigation on all irrigable and conditionally irrigable soils in North Dakota (Figure 4) . The entire range of electrical conductivities (350 to 980 μS/cm) is also suitable for all irrigable and conditionally irrigable soils in North Dakota (Figure 5).

In general, water quality in the study area is suitable for irrigation. From Figures 4 and 5 , nearly all of the Warwick aquifer samples were suitable for irrigation, and about 95% of the Spiritwood aquifer samples were suitable for irrigation. Water suitability for irrigation, based on an upper limit of 1,500 μS/cm for electrical conductivity and 6 for SAR, is shown for wells in the Spiritwood and Warwick aquifers on Figure 6.

THE COMBINED SOIL AND WATER INDEX

Combined Soil and Water Index for Sandy Soils

A Combined Index of soil suitability and water availability was derived by multiplying the Composite Soil Irrigability Index (three levels, Table 3) by the Water Availability Index (four levels, Table 4). The Combined Index is thus scaled from 1 through 12. **A Combined Index of one or two indicates tracts with high probability of good water supply and also excellent soils for irrigation. A Combined Index of three or four indicates a reasonably high probability of having good local soils and adequate water.** An index larger than four indicates that either the parts of the tract will have limitations such as shallow gravel, or wetness, or water supplies might be limiting. A Combined Index of 12 would indicate a

soil with a substantial portion (25 to 50%) of the land having irrigation limitations within the tract, and a high probability of a shallow aquifer with low pumpage and limited areal extent. However, even some tracts with an index of 12 may prove to be productive as irrigable land.

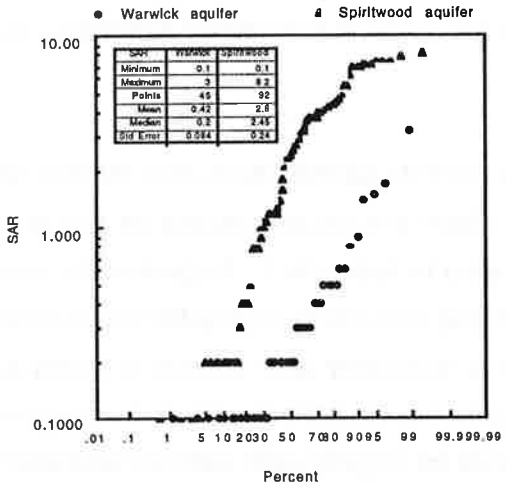

Figure 4. Probability distribution of SAR for water samples taken from the Warwick and Spiritwood aquifers in the area of study.

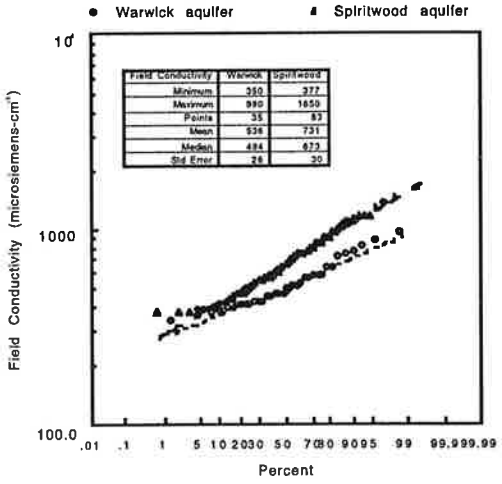

Figure 5. Probability distribution of electrical conductivity of water samples taken from the Warwick and Spiritwood aquifers in the area of study.

Combined Soil and Water Index for Loamy Soils

The Combined Index of soil suitability and water availability for loamy soils was simplified because only one soil category was applied. That is, only loamy soils that are irrigable without limitation, and mapped as occupying the entire 40-acre tract either alone, or in combination with irrigable sandy soils, were used. Because there was only one soil category, the Combined Soil and Water Index for loams is thus identical to the Water Availability Index, and is scaled 1 through 4, rather than 1 through 12.

RESULTS OF COMBINED SOIL AND WATER INDEX

Combined Soil and Water Indices are mapped on Figure 6. Combined indices and locations of each tract are listed in Appendix 1. In general, for sands indices of 1 through 4 indicate a high likelihood of finding soil suitable for irrigation and sufficient available water. Indices from 5 through 12 also offer a reasonably good chance of finding suitable soil and water, but limitations are more likely to be incurred. For loams, indices of one and two indicate a high likelihood of finding soil suitable for irrigation with sufficient available water. Indices of 3 and 4 indicate a higher likelihood of having insufficient water.

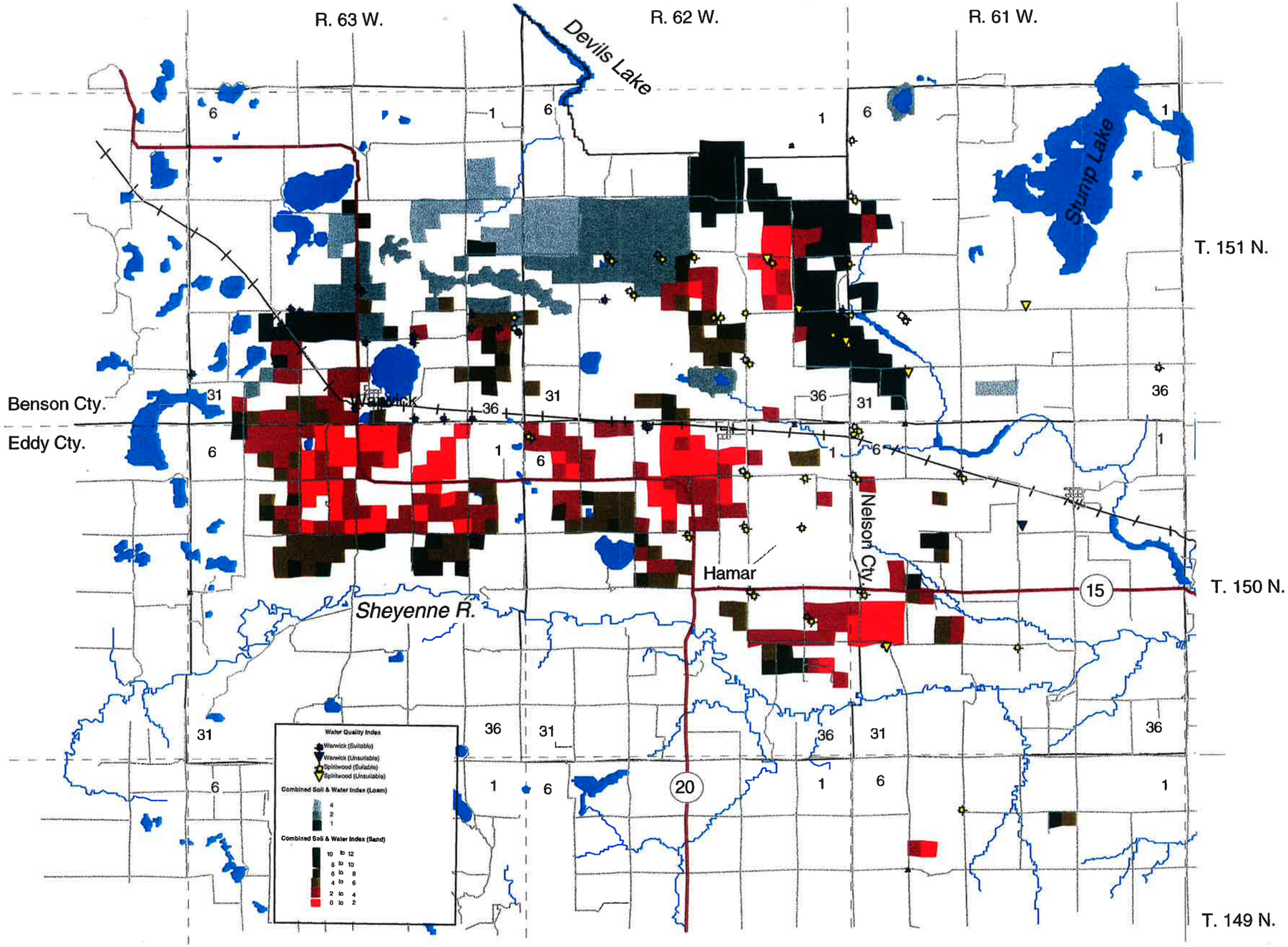

Figure 6. Map evaluation of land tracts most suitable for irrigation, using the Combined Soil and Water Index described on page 34.

POTENTIAL IRRIGATION DEVELOPMENT

A summary of Combined Soil and Water Indices indicates that in the Warwick aquifer area of Benson, Eddy, and Nelson counties, there are about 19,640 acres of land identified in tracts of 40-acres or more that have a high probability of having both soil and water suitable for irrigation, with few limitations. Of these, about 12,280 acres have soils classified as sandy, while about 7,360 acres have soils classified as loamy. Water permits have already been granted (May, 1999) for 5,627 acres in the townships studied. Assuming that most currently developed permitted acreage would be in the tracts mapped as suitable, there would remain about 14,000 acres in 40-acre tracts with soil and water supplies highly suitable for irrigation.

Figure 7 (and the included table) show the distribution of current and potential future irrigation development based on these criteria. The largest block of current development is in T. 151 N R. 62 W (Minco township, Benson County). Most potential future development would be in a four township area identified as T. 150 N R. 62 W (Freeborn Township, Eddy County) , T. 150 N R. 63 W (Eddy Township, Eddy County), T. 151 N R. 62 W (Minco Township, Benson County) and T. 151 N R. 63 W (Warwick Township, Benson County). If sandy soils are preferred, T. 150 N R. 62 W (Freeborn Township, Eddy County) , and T. 150 N R. 63 W (Eddy Township, Eddy County) would have the highest development potential. Locations of sandy tracts are shown in Appendix 1a. If loamy soils are preferred, T. 151 N R. 62 W (Minco Township, Benson County) would have the highest development potential. These are shown in Appendix 1b. T. 151 N R. 63 W (Warwick Township, Benson County) would have about equal potential for development of sands and loams. Potential future development acreage (N) is listed for each township on figure 1.

There were an additional 46 tracts (40 acres), or about 1,840 acres, with sandy soils having some limitations and a lesser possibility of having a good water supply. There were also an additional 46 tracts (1,840 acres) with loamy soils, but some (lesser) potential for development. Each of these has more than fifty percent of its surface areas mapped to soils classified as irrigable without limitation, and each is mapped as having some aquifer area underlying it. In addition to these, there are likely many areas mapped to soils that are irrigable with limitations that might be developed for irrigation using appropriate management measures, such as surface or tile drainage, or limited irrigation rates.

Although 40-acre tracts are mapped in this study, irrigation development usually requires larger units. Each tract was evaluated for its potential capability for combination with other 40-acre tracts to form 80-acre and 160-acre development units. Combinations were not limited by quarter-section or section lines. Rather, any potential combination of contiguous tracts not divided by an improved road or other obstacle was considered. Potential combinations are listed on Table 5.

About 96% of all tracts listed could potentially be combined to form 80-acre development units. About 72% could be combined to form 160-acre development units.

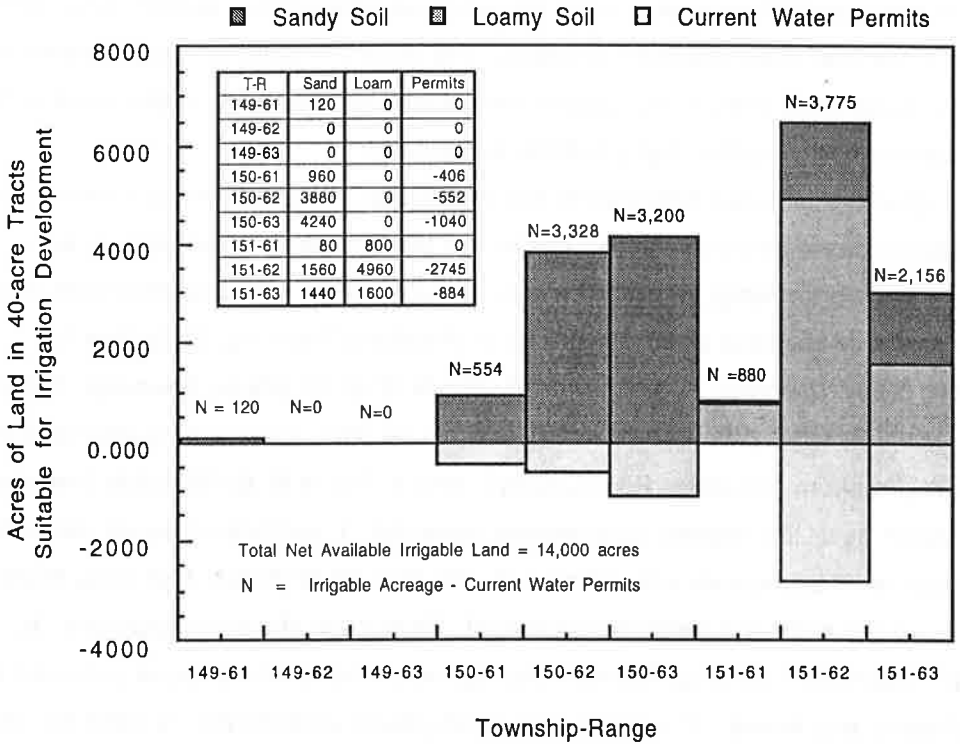

Figure 7. Net acreage available for irrigation development, and current acreage under water permit for irrigation by township. Acreage estimates are based on numbers of 40-acre tracts having a Combined Soil and Water Index of 1 through 4; and loamy soils having a Combined Soil and Water Index of 1 through 2.

SUMMARY

Six townships overlying the Warwick and Spiritwood aquifers in Benson, Eddy, and Nelson Counties were evaluated for potential irrigation development. Soil criteria used were stringent, including only soils classed as irrigable without limitation for most, or all of the identified tract. Drainage classes were moderately well-drained to well-drained. Forty-acre tracts having soils suitable for irrigation and likely suitable water supply were evaluated in a Combined Soil and Water Index. Results (rounded to the nearest 500 acres) indicated that there were about 19,500 acres likely available for irrigation development, of which12,000 acres were sandy, and about 7,500 were loamy. These included about 5,500 acres already permitted for irrigation. Additional

potential development is about 14,000 acres. Most of the sandy tracts available are located in T. 150 N R. 62 W (Freeborn Township, Eddy County), and T. 150 N R. 63 W (Eddy Township, Eddy County) . Most of the loamy tracts available are in T. 151 N R. 62 W (Minco Township, Benson County). Potential development of both loamy and sandy soils is about equal in T. 151 N R. 63 W (Warwick Township, Benson County). About 13,000 acres (96%) might be combined in tracts of 80 acres, while about 10,000 acres might be developed in combined tracts of 160 acres. Potential water supplies are generally of a quality suitable for irrigation.

Soil suitability for irrigation is mapped on Figure 2. Water availability for irrigation is mapped on Figure 3. Combined soil and water suitability and availability are mapped on Figure 6. Water quality suitability for irrigation is shown on Figure 6. Soil and Water indices shown on the maps are listed in Appendix I-A for sands, and in Appendix I-B for loams. Water quality for each location shown on Figure 6 is listed in Appendix II. Specific soil limitations for each location mapped on Figure 2 are listed in Table 5. Potential combinations of tracts to form larger (80- and 160-acre) units are also listed in Table 5.

The purpose of this report is to help locate potential tracts for irrigation development. While soil and aquifer maps have been carefully checked for these determinations, they are limited to the accuracy of the maps themselves. In addition, changing climatic conditions can effect the irrigability of some mapping units. It is strongly advised that users field check soil and water availability before initiating actual development. In addition, the user should note that there will likely be other tracts of land, not listed under our criteria, that would be suitable for irrigation development with appropriate management.

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USDA-SCS. 1989. Soil Survey of Nelson County, North Dakota. U.S. Department of Agriculture Soil Conservation Service.

USDA-SCS. 1979. Soil Survey of Benson County, North Dakota. U.S. Department of Agriculture Soil Conservation Service.

USDA-SCS. 1977. Soil Survey of Eddy County, North Dakota. U.S. Department of Agriculture Soil Conservation Service.

APPENDIX I-A (Sandy Soils)

List of locations, Soil Suitability Index (SOIL INDEX) , Water Availability Index (H2O INDEX), and Combined Index (COMBINED SW) for each of the 40-acre tracts evaluated that have soils with sandy texture. Tracts are listed in ascending order.

LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW	LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW
14906108CA	1	1	1	15006225BD	1	1	1
14906110AA	1	4	4	15006226BA	1	4	4
14906111AB	1	0	0	15006302AA	1	1	1
15006117AC	1	4	4	15006302AC	1	1	1
15006118DA	1	2	2	15006302CA	1	1	1
15006118DD	1	2	2	15006302CC	1	1	1
15006119AC	1	1	1	15006302CD	1	1	1
15006119AD	1	1	1	15006302DB	1	1	1
15006119BC	1	1	1	15006302DC	1	1	1
15006119BD	1	1	1	15006303AB	1	1	1
15006119CA	1	1	1	15006303AC	1	1	1
15006119CB	1	1	1	15006303BA	1	1	1
15006119CC	1	1	1	15006303BB	1	1	1
15006119CD	1	1	1	15006303BC	1	1	1
15006119DB	1	1	1	15006303BD	1	1	1
15006119DC	1	1	1	15006303DB	1	1	1
15006120BA	1	2	2	15006304AB	1	1	1
15006120DA	1	2	2	15006304AC	1	1	1
15006120DD	1	2	2	15006304AD	1	1	1
15006202CB	1	2	2	15006304BA	1	1	1
15006203BC	1	1	1	15006304BD	1	1	1
15006203CA	1	1	1	15006304CB	1	1	1
15006203CB	1	1	1	15006304CC	1	1	1
15006203CC	1	1	1	15006304DA	1	1	1
15006203CD	1	1	1	15006304DB	1	1	1
15006203DA	1	1	1	15006305AA	1	2	2
15006203DB	1	1	1	15006305AB	1	2	2
15006204AA	1	1	1	15006305AC	1	2	2
15006204AB	1	1	1	15006305AD	1	2	2
15006204AC	1	1	1	15006305BA	1	2	2
15006204DA	1	1	1	15006305BB	1	2	2
15006204DB	1	1	1	15006305BC	1	2	2
15006204DC	1	1	1	15006305BD	1	2	2
15006204DD	1	1	1	15006305DB	1	2	2
15006206DB	1	1	1	15006305DD	1	2	2
15006206DD	1	1	1	15006308AA	1	2	2
15006207AC	1	2	2	15006308DA	1	2	2
15006207AD	1	2	2	15006308DB	1	2	2
15006207DA	1	2	2	15006308DD	1	2	2
15006209AC	1	1	1	15006309AB	1	1	1
15006209BA	1	1	1	15006309AC	1	1	1
15006209BD	1	1	1	15006309BA	1	1	1
15006209DB	1	1	1	15006309BB	1	1	1
15006210AB	1	1	1	15006309BC	1	1	1
15006210AC	1	1	1	15006309CC	1	1	1
15006212BD	1	2	2	15006309DB	1	1	1
15006216BC	1	2	2	15006309DD	1	1	1
15006216CA	1	2	2	15006310CA	1	1	1
15006216DB	1	2	2	15006310CC	1	1	1
15006218CC	1	0	0	15006310CD	1	1	1
15006218CD	1	0	0	15006311AC	1	1	1
15006220BB	1	0	0	15006311BA	1	1	1
15006222AC	1	4	4	15006311CB	1	1	1
15006222AD	1	4	4	15006311DD	1	1	1
15006222DA	1	4	4	15006312CA	1	2	2
15006224DA	1	1	1	15006312CB	1	2	2
15006224DD	1	1	1	15006312CC	1	2	2

LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW	LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW
15006314AA	1	4	4	15006115DB	2	0	0
15006314AB	1	4	4	15006116BD	2	0	0
15006314AC	1	4	4	15006116CD	2	0	0
15006314AD	1	4	4	15006116DC	2	0	0
15006314BD	1	4	4	15006116DD	2	0	0
15006316AA	1	4	4	15006117AB	2	4	8
15006316AB	1	4	4	15006117BA	2	4	8
15006316AC	1	4	4	15006117CC	2	4	8
15006316BA	1	4	4	15006119DA	2	1	2
15006316BB	1	4	4	15006119DD	2	1	2
15006316BC	1	4	4	15006120BB	2	2	4
15006316BD	1	4	4	15006120DB	2	2	4
15006316CB	1	4	4	15006120DC	2	2	4
15006317AA	1	4	4	15006121CC	2	0	0
15006317AC	1	4	4	15006121CD	2	0	0
15006317AD	1	4	4	15006121DC	2	0	0
15006317DB	1	4	4	15006121DD	2	0	0
15106214DA	1	1	1	15006201CA	2	2	4
15106214DB	1	1	1	15006201CB	2	2	4
15106214DC	1	1	1	15006204AD	2	1	2
15106214DD	1	1	1	15006205AB	2	1	2
15106221DA	1	2	2	15006205CC	2	1	2
15106221DB	1	2	2	15006206AB	2	1	2
15106221DC	1	2	2	15006206AC	2	1	2
15106222CB	1	1	1	15006206AD	2	1	2
15106223AA	1	1	1	15006206BB	2	1	2
15106223AB	1	1	1	15006206BC	2	1	2
15106223AC	1	1	1	15006206DA	2	1	2
15106223BA	1	1	1	15006207DD	2	2	4
15106223DB	1	1	1	15006208AC	2	2	4
15106223DD	1	1	1	15006208AD	2	2	4
15106310DA	1	0	0	15006208BD	2	2	4
15106325AC	1	2	2	15006208CA	2	2	4
15106325BC	1	2	2	15006208CC	2	2	4
15106326BC	1	2	2	15006208CD	2	2	4
15106331DA	1	2	2	15006208DA	2	2	4
15106332AA	1	2	2	15006208DB	2	2	4
15106332AB	1	2	2	15006208DD	2	2	4
15106332CD	1	2	2	15006209CC	2	1	2
15106332DC	1	2	2	15006209DC	2	1	2
15106332DD	1	2	2	15006210BA	2	1	2
15106333AA	1	2	2	15006210BB	2	1	2
15106333AB	1	2	2	15006210CA	2	1	2
15106333AC	1	2	2	15006210CD	2	1	2
15106333AD	1	2	2	15006210DA	2	1	2
15106333CA	1	2	2	15006210DB	2	1	2
15106333DB	1	2	2	15006216BD	2	2	4
15106333DC	1	2	2	15006216CD	2	2	4
15106333DD	1	2	2	15006216DA	2	2	4
15106334BB	1	2	2	15006216DC	2	2	4
14906103CC	2	0	0	15006218AA	2	0	0
14906108CB	2	1	2	15006218AB	2	0	0
14906110AB	2	4	8	15006218BA	2	0	0
15006107BA	2	1	2	15006218CA	2	0	0
15006108AC	2	2	4	15006218DC	2	0	0
15006114CA	2	0	0	15006218DD	2	0	0
15006115AC	2	0	0	15006219AA	2	0	0

LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW	LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW
15006219AB	2	0	0	15106227BA	2	2	4
15006221AA	2	0	0	15106227BC	2	2	4
15006222BB	2	4	8	15106227CA	2	2	4
15006223CC	2	1	2	15106227CB	2	2	4
15006223CD	2	1	2	15106227CD	2	2	4
15006224CC	2	1	2	15106227DA	2	2	4
15006224CD	2	1	2	15106227DB	2	2	4
15006224DB	2	1	2	15106230BB	2	2	4
15006225DB	2	1	2	15106231BC	2	2	4
15006226AB	2	4	8	15106233CA	2	2	4
15006226AC	2	4	8	15106233CB	2	2	4
15006226AD	2	4	8	15106233DD	2	2	4
15006226BD	2	4	8	15106235CD	2	1	2
15006303AD	2	1	2	15106311CB	2	0	0
15006303CA	2	1	2	15106315BC	2	4	8
15006303CB	2	1	2	15106322CC	2	2	4
15006303CC	2	1	2	15106323DC	2	2	4
15006304BB	2	1	2	15106325AB	2	2	4
15006304CA	2	1	2	15106325BA	2	2	4
15006304DC	2	1	2	15106325BB	2	2	4
15006305CA	2	2	4	15106325DB	2	2	4
15006305DA	2	2	4	15106329DA	2	1	2
15006305DC	2	2	4	15106329DB	2	1	2
15006306AA	2	4	8	15106329DD	2	1	2
15006308BD	2	2	4	15106332CC	2	2	4
15006308DC	2	2	4	15106332DA	2	2	4
15006309AA	2	1	2	15106333CB	2	2	4
15006309AD	2	1	2	15106333CC	2	2	4
15006309DA	2	1	2	15106333CD	2	2	4
15006309DC	2	1	2	15106334CD	2	2	4
15006310CB	2	1	2	15106335AA	2	2	4
15006310DA	2	1	2	15106336AB	2	2	4
15006310DC	2	1	2	14906103CA	3	0	0
15006310DD	2	1	2	14906103CD	3	0	0
15006311AD	2	1	2	14906103DB	3	0	0
15006311BC	2	1	2	14906103DC	3	0	0
15006311BD	2	1	2	14906111AA	3	0	0
15006311CA	2	1	2	14906111AC	3	0	0
15006311CC	2	1	2	14906111BA	3	0	0
15006311DA	2	1	2	14906111BD	3	0	0
15006311DB	2	1	2	15006121AD	3	0	0
15006312BA	2	2	4	15006203DC	3	1	3
15006312BB	2	2	4	15006204CC	3	1	3
15006312BD	2	2	4	15006205AA	3	1	3
15006312CD	2	2	4	15006205BA	3	1	3
15006313BB	2	4	8	15006205CB	3	1	3
15006314CA	2	4	8	15006206BD	3	1	3
15006314CB	2	4	8	15006206DC	3	1	3
15006314DA	2	4	8	15006207DB	3	2	6
15006317DA	2	4	8	15006208BC	3	2	6
15106213CC	2	1	2	15006208DC	3	2	6
15106221DD	2	2	4	15006209AA	3	1	3
15106222BC	2	1	2	15006209AB	3	1	3
15106222CA	2	1	2	15006209AD	3	1	3
15106223AD	2	1	2	15006210BC	3	1	3
15106223DA	2	1	2	15006210BD	3	1	3
15106223DC	2	1	2	15006210CC	3	1	3

LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW	LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW
15006216BB	3	2	6				
15006216CC	3	2	6				
15006218BC	3	0	0				
15006218BD	3	0	0				
15006223DC	3	1	3				
15006223DD	3	1	3				
15006224AC	3	1	3				
15006224AD	3	1	3				
15006224BC	3	1	3				
15006224BD	3	1	3				
15006224CA	3	1	3				
15006225BC	3	1	3				
15006303AA	3	1	3				
15006304CD	3	1	3				
15006308AD	3	2	6				
15006308CA	3	2	6				
15006309CD	3	1	3				
15006314BA	3	4	12				
15006314BC	3	4	12				
15006315BA	3	4	12				
15006315BB	3	4	12				
15006316CA	3	4	12				
15106118BD	3	1	3				
15106118CA	3	1	3				
15106213CA	3	1	3				
15106213CB	3	1	3				
15106221AA	3	2	6				
15106221AD	3	2	6				
15106222BD	3	1	3				
15106222CD	3	1	3				
15106225BC	3	1	3				
15106227AC	3	2	6				
15106227AD	3	2	6				
15106227BB	3	2	6				
15106227DC	3	2	6				
15106233DB	3	2	6				
15106233DC	3	2	6				
15106313CC	3	4	12				
15106313CD	3	4	12				
15106316AA	3	4	12				
15106325BD	3	2	6				
15106325CA	3	2	6				
15106325DC	3	2	6				
15106327AC	3	2	6				
15106331DD	3	2	6				
15106336BA	3	2	6				
15106336BB	3	2	6				
15106336BD	3	2	6				

APPENDIX 1-B (Loamy Soils)

List of locations, Soil Suitability Index (SOIL INDEX) , Water Availability Index (H2O INDEX), and Combined Index (COMBINED SW) for each of the 40-acre tracts evaluated that have soils with loamy texture. Tracts are listed in ascending order.

LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW	LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW
14906111BB	4	0	0	15106213AB	4	1	1
15006220BA	4	0	0	15106213AC	4	1	1
15106118AC	4	1	1	15106213AD	4	1	1
15106118BA	4	1	1	15106213BA	4	1	1
15106118BC	4	1	1	15106213BB	4	1	1
15106118CB	4	1	1	15106213BC	4	1	1
15106119CA	4	1	1	15106213BD	4	1	1
15106119CB	4	1	1	15106213CD	4	1	1
15106119CD	4	1	1	15106213DA	4	1	1
15106130BC	4	1	1	15106213DB	4	1	1
15106130CA	4	1	1	15106213DC	4	1	1
15106130CB	4	1	1	15106213DD	4	1	1
15106130CC	4	1	1	15106214AA	4	1	1
15106130CD	4	1	1	15106214AB	4	1	1
15106130DC	4	1	1	15106214AC	4	1	1
15106131AA	4	1	1	15106214AD	4	1	1
15106131AB	4	1	1	15106214BA	4	1	1
15106131AC	4	1	1	15106214BB	4	1	1
15106131AD	4	1	1	15106215AA	4	1	1
15106131BA	4	1	1	15106215AB	4	1	1
15106131BB	4	1	1	15106215BA	4	1	1
15106131DA	4	1	1	15106215BB	4	1	1
15106133AC	4	4	4	15106215BD	4	1	1
15106133AD	4	4	4	15106216AA	4	2	2
15106133BD	4	4	4	15106216AB	4	2	2
15106134AC	4	0	0	15106216AC	4	2	2
15106134AD	4	0	0	15106216AD	4	2	2
15106134BC	4	0	0	15106216BA	4	2	2
15106134BD	4	0	0	15106216BB	4	2	2
15106134DA	4	0	0	15106216BC	4	2	2
15106135BC	4	0	0	15106216BD	4	2	2
15106135BD	4	0	0	15106216CA	4	2	2
15106135CA	4	0	0	15106216CB	4	2	2
15106135CD	4	0	0	15106216CC	4	2	2
15106210AA	4	1	1	15106216CD	4	2	2
15106210AB	4	1	1	15106216DA	4	2	2
15106210AC	4	1	1	15106216DB	4	2	2
15106210AD	4	1	1	15106216DC	4	2	2
15106210BA	4	1	1	15106216DD	4	2	2
15106210BC	4	1	1	15106217AA	4	2	2
15106210BD	4	1	1	15106217AB	4	2	2
15106210CA	4	1	1	15106217AC	4	2	2
15106210CB	4	1	1	15106217AD	4	2	2
15106210CC	4	1	1	15106217BA	4	2	2
15106210CD	4	1	1	15106217BB	4	2	2
15106210DA	4	1	1	15106217BC	4	2	2
15106210DB	4	1	1	15106217BD	4	2	2
15106210DC	4	1	1	15106217CA	4	2	2
15106210DD	4	1	1	15106217CB	4	2	2
15106211BB	4	1	1	15106217CC	4	2	2
15106211BC	4	1	1	15106217CD	4	2	2
15106211CA	4	1	1	15106217DA	4	2	2
15106211CB	4	1	1	15106217DB	4	2	2
15106211CC	4	1	1	15106217DC	4	2	2
15106211CD	4	1	1	15106217DD	4	2	2
15106211DC	4	1	1	15106218AA	4	4	4
15106213AA	4	1	1	15106218AB	4	4	4

LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW	LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW
15106218AC	4	4	4	15106225DC	4	1	1
15106218AD	4	4	4	15106225DD	4	1	1
15106218BA	4	4	4	15106310AA	4	0	0
15106218BB	4	4	4	15106310AB	4	0	0
15106218BC	4	4	4	15106310AC	4	0	0
15106218BD	4	4	4	15106310AD	4	0	0
15106218CA	4	4	4	15106310BA	4	0	0
15106218CB	4	4	4	15106310BC	4	0	0
15106218CC	4	4	4	15106310BD	4	0	0
15106218CD	4	4	4	15106310CA	4	0	0
15106218DA	4	4	4	15106310CB	4	0	0
15106218DB	4	4	4	15106310CD	4	0	0
15106218DC	4	4	4	15106310DB	4	0	0
15106218DD	4	4	4	15106311AA	4	0	0
15106219AA	4	2	2	15106311AB	4	0	0
15106219AB	4	2	2	15106311AC	4	0	0
15106219AC	4	2	2	15106311AD	4	0	0
15106219AD	4	2	2	15106311BA	4	0	0
15106219BA	4	2	2	15106311BB	4	0	0
15106219BB	4	2	2	15106311BC	4	0	0
15106220AA	4	2	2	15106311BD	4	0	0
15106220AB	4	2	2	15106311CA	4	0	0
15106220AC	4	2	2	15106311CC	4	0	0
15106220AD	4	2	2	15106311CD	4	0	0
15106220BB	4	2	2	15106311DA	4	0	0
15106220BC	4	2	2	15106311DB	4	0	0
15106220BD	4	2	2	15106311DC	4	0	0
15106221AB	4	2	2	15106311DD	4	0	0
15106221AC	4	2	2	15106312BC	4	4	4
15106221BA	4	2	2	15106312BD	4	4	4
15106221BB	4	2	2	15106312CA	4	4	4
15106221BC	4	2	2	15106312CB	4	4	4
15106221BD	4	2	2	15106312CC	4	4	4
15106221CA	4	2	2	15106312CD	4	4	4
15106221CB	4	2	2	15106312DC	4	4	4
15106224AA	4	1	1	15106313AD	4	4	4
15106224AC	4	1	1	15106313BB	4	4	4
15106224BB	4	1	1	15106313CA	4	4	4
15106224BC	4	1	1	15106313DA	4	4	4
15106224BD	4	1	1	15106313DB	4	4	4
15106224CA	4	1	1	15106313DC	4	4	4
15106224CB	4	1	1	15106313DD	4	4	4
15106224CC	4	1	1	15106313DD	4	4	4
15106224CD	4	1	1	15106314AA	4	4	4
15106224DB	4	1	1	15106314AB	4	4	4
15106224DC	4	1	1	15106314BA	4	4	4
15106225AA	4	1	1	15106314BB	4	4	4
15106225AB	4	1	1	15106314BC	4	4	4
15106225AC	4	1	1	15106314BD	4	4	4
15106225AD	4	1	1	15106314CB	4	4	4
15106225BA	4	1	1	15106315CC	4	2	2
15106225BB	4	1	1	15106316AC	4	4	4
15106225BD	4	1	1	15106316AD	4	4	4
15106225CA	4	1	1	15106316DA	4	4	4
15106225CD	4	1	1	15106316DB	4	4	4
15106225DA	4	1	1	15106316DC	4	4	4
15106225DB	4	1	1	15106321AA	4	2	2

LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW	LOCATION	SOIL INDEX	WATER INDEX	COMBINED SW
15106321AD	4	2	2				
15106321CA	4	2	2				
15106321CD	4	2	2				
15106321DA	4	2	2				
15106321DB	4	2	2				
15106321DC	4	2	2				
15106321DD	4	2	2				
15106322BB	4	2	2				
15106322BC	4	2	2				
15106322CA	4	2	2				
15106322CB	4	2	2				
15106323AA	4	2	2				
15106323CD	4	2	2				
15106324CC	4	2	2				
15106324CD	4	2	2				
15106324DC	4	2	2				
15106325AA	4	2	2				
15106327BA	4	2	2				
15106327BB	4	2	2				
15106327BC	4	2	2				
15106327BD	4	2	2				
15106328AA	4	1	1				
15106328AB	4	1	1				
15106328AC	4	1	1				
15106328AD	4	1	1				
15106328BA	4	1	1				
15106328BB	4	1	1				
15106328BC	4	1	1				
15106328BD	4	1	1				
15106329AA	4	1	1				
15106329AA	4	1	1				
15106329AC	4	1	1				
15106329AD	4	1	1				
15106329BA	4	1	1				
15106329BD	4	1	1				
15106329DC	4	1	1				
15106332BA	4	2	2				
15106332BC	4	2	2				

APPENDIX II (Water Quality)

List of dates, sodium adsorption ratios (SAR), field and laboratory electrical conductivities, and the water suitability (QW) Index, by location, for water samples taken from wells in the Spiritwood and Warwick aquifers in Benson, Eddy, and Nelson Counties.

Location	Date Sampled	Aquifer	Field-Conduct	Lab-Conduct	SAR	QW Index
15006204BBA	8/7/91	Warwick	386	398	0.1	1
15006204BBA2	8/7/91	Warwick	457	473	0.1	1
15006313BBB	6/24/87	Warwick	870	827	0.2	1
15106220CDA	7/17/97	Warwick	367	401	0.2	1
15106220DAD2	7/16/97	Warwick	392	423	0.3	1
15106223ABB3	8/15/91	Warwick	571	584	0.1	1
15106224CCC3	7/16/97	Warwick	521	590	0.1	1
15106224DDC3	8/15/91	Warwick	980	1010	0.1	1
15106224DDC3	7/16/97	Warwick	829	1010	0.1	1
15106225DAA3	7/16/97	Warwick	721	849	0.2	1
15106320DDC	7/7/88	Warwick	638	492	0.2	1
15106320DDD	6/25/87	Warwick	470	442	0.9	1
15106320DDD2	7/7/78	Warwick	520	525	0.6	1
15106322CBB	7/15/97	Warwick	428	474	0.4	1
15106325ACB	6/25/68	Warwick		396	0.2	1
15106325ADB1	7/11/68	Warwick		512	0.2	1
15106325ADB2	6/25/68	Warwick		457	0.5	1
15106325ADB3	6/25/68	Warwick		489	0.4	1
15106325BBB	6/24/88	Warwick	484	471	0.2	1
15106325BCB1	7/17/97	Warwick	414	450	0.2	1
15106326BCC	5/7/69	Warwick		586	0.6	1
15106326CBB	5/7/69	Warwick		725	0.8	1
15106327CBA	5/7/69	Warwick		519	0.3	1
15106328ADA	10/9/67	Warwick		399	0.1	1
15106329AAC2	9/24/86	Warwick	420	408	0.1	1
15106329ABDC	6/25/87	Warwick	740	740		1
15106329ACBD	11/29/84	Warwick	590	593	1.5	1
15106329DCC	7/23/81	Warwick	591	584	1.7	1
15106331BBB	7/22/68	Warwick		1490	3.2	1
15106333DAD	7/17/97	Warwick	504	566	0.3	1
15106334CAA	8/9/91	Warwick	530	535	0.4	1
15106335DCC	5/7/69	Warwick		435	0.5	1
15106336CCC	8/29/68	Warwick	350	446	0.1	1
15006110CCC	8/7/69	Warwick		2390	1.4	2
14906105DDD	6/5/70	Spiritwood		980	1.6	1
14906133CCC	7/10/80	Spiritwood	750	668	0.4	1
14906134DCC	7/10/80	Spiritwood	820	673	0.5	1
15006105DDD	7/15/97	Spiritwood	859	1050	4.2	1
15006106BBB	7/16/97	Spiritwood	494	546	2.3	1
15006106BBC	6/25/87	Spiritwood	670	633	4.2	1
15006106CCC2	7/16/97	Spiritwood	509	566	3.7	1
15006119BBB	7/15/97	Spiritwood	975	1180	4.7	1
15006128AAA	8/6/69	Spiritwood		1380	3.2	1
15006130ABB	7/15/97	Spiritwood	1185	1510	7	2
15006203DDD	7/14/95	Spiritwood	490	524	0.2	1
15006206BBC	7/15/97	Spiritwood	475	533	1	1
15006210DDD	7/15/97	Spiritwood	446	490	1.2	1
15006212BBB	11/10/83	Spiritwood	610	601	3.4	1
15006212CCCB	6/24/87	Spiritwood	590	548	3.3	1
15006216AAA	7/15/97	Spiritwood	438	489	0.9	1
15006223BBB	7/15/97	Spiritwood	969	1200	5	1
15006224CBB	7/15/97	Spiritwood	560	648	3.8	1
15106106CCC	7/10/97	Spiritwood	862	1100	0.8	1
15106107CCC	7/10/97	Spiritwood	765	964	0.2	1
15106130BBB	6/24/87	Spiritwood	730	671	2.7	1
15106132BBB	7/16/97	Spiritwood	923	1060	7.5	2

Location	Date Sampled	Aquifer	Field-Conduct	Lab-Conduct	SAR	QW Index
15106136ABB	6/28/68	Spiritwood		888	0.2	1
15106220ABB	7/17/97	Spiritwood	386	415	0.2	1
15106220DAD1	7/16/97	Spiritwood	377	404	0.1	1
15106221BAA	7/21/95	Spiritwood	870	933	4.7	1
15106222BBB2	7/21/95	Spiritwood	690	748	3	1
15106223ABB	7/10/97	Spiritwood	579	677	3.8	1
15106223ABB2	7/10/97	Spiritwood	429	491	2.1	1
15106224AAA	7/10/97	Spiritwood	401	448	0.5	1
15106224CCC2	7/16/97	Spiritwood	539	596	2.9	1
15106225ACD	8/1/84	Spiritwood	820	752	5.6	1
15106225DAA1	7/16/97	Spiritwood	1046	1200	8.2	2
15106225DAA2	8/8/91	Spiritwood	753	782	3.8	1
15106227AAA2	7/18/91	Spiritwood	578	600	1.4	1
15106227ABC	6/29/88	Spiritwood	750	703	1.8	1
15106227BAD	8/7/80	Spiritwood	770	715	1.2	1
15106227DDDA	7/16/97	Spiritwood	582	652	2.4	1
15106325AAB	7/17/97	Spiritwood	412	452	0.3	1
15006130ABB	7/17/91	Spiritwood	1464	1530	7	2
15106122CCD	7/29/69	Spiritwood		1370	7.2	2
15106132BBB	7/16/91	Spiritwood	978	1050	7.5	2
15106223ABB	7/18/91	Spiritwood	658	680	3.8	1
15106224CCC	7/18/91	Spiritwood	843	887	7.2	2
15106225DAA1	8/8/91	Spiritwood	1172	1210	7.8	2
15106325AAB	6/24/87	Spiritwood	470	453	0.4	1