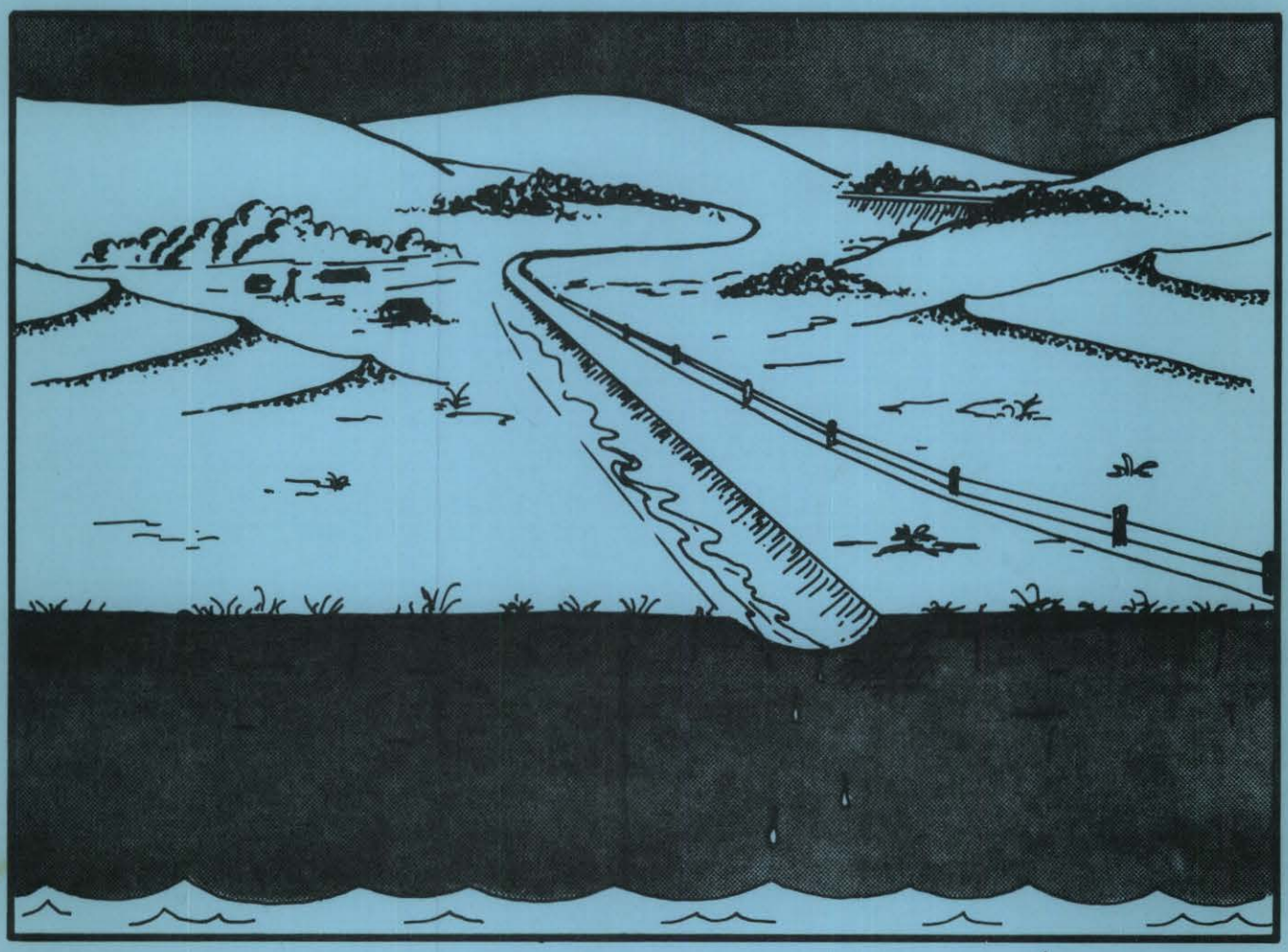
LEWIS & CLARK NRD GROUNDWATER MANAGEMENT PLAN UPDATE - JULY 1, 1993

INCLUDES Original 1986 Plan and
1993 - 1995 Water Quality updates as Approved

WRP 752 MT

LEWIS & CLARK
NATURAL RESOURCES DISTRICT



Groundwater Management Plan

NOTE:
This Binder Contains Both the 1986 Plan and The 1993-1995 Water Quality Update

1986

RECEIVED

DEC 9 1985

NEBRASKA NATURAL
RESOURCES COMMISSION

LEWIS AND CLARK NATURAL RESOURCES DISTRICT
NATURAL RESOURCES DISTRICT
GROUNDWATER MANAGMENT PLAN

JANUARY 1986

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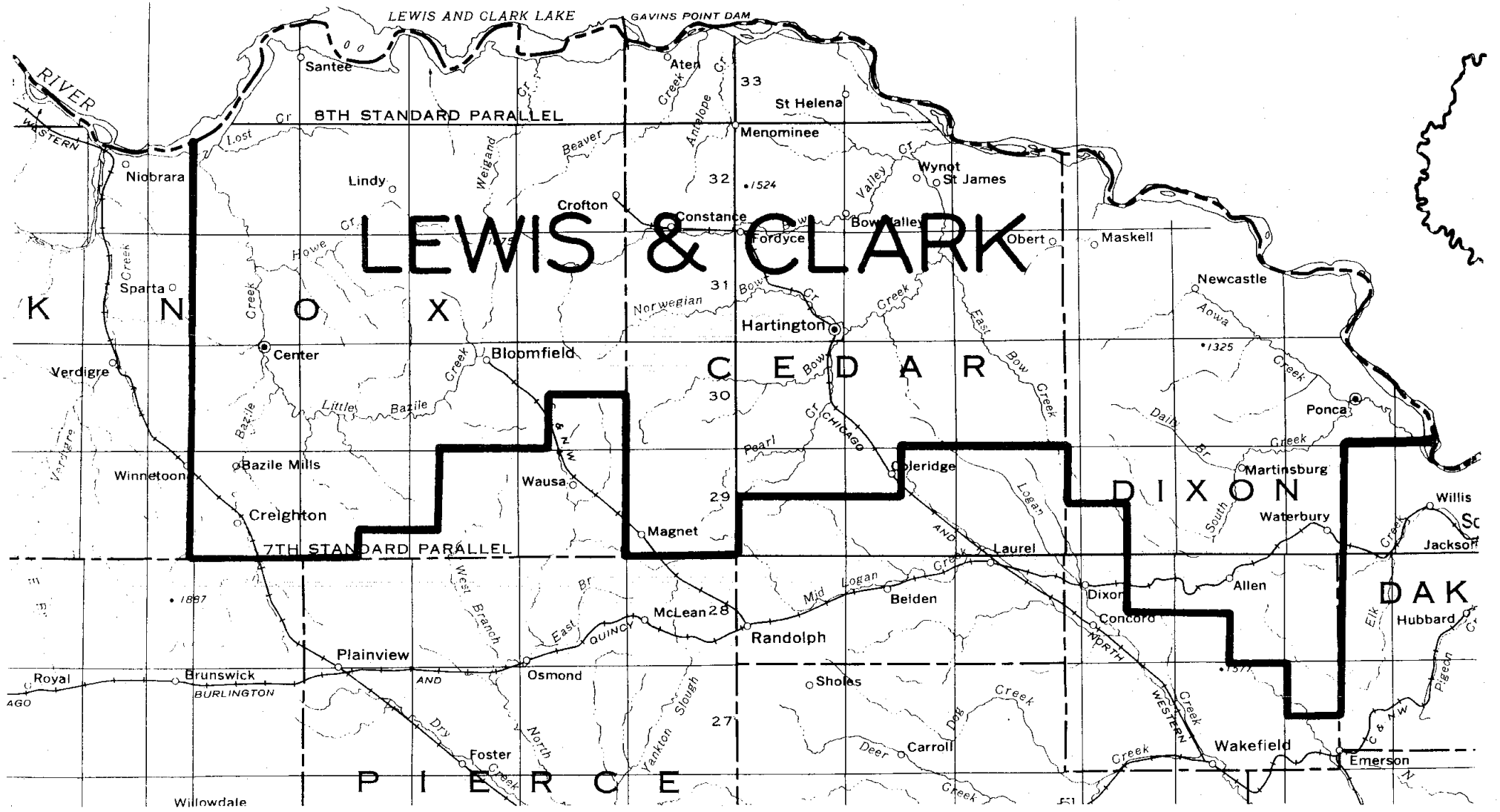
LEWIS & CLARK
LEWIS AND CLARK LAKE
GAVINS POINT DAM
8TH STANDARD PARALLEL
7TH STANDARD PARALLEL
K N O X
C E D A R
D I X O N
P I E R C E
DAK
Santee
Aten
St Helena
Menominee
Niobrara
Lindy
Crofton
Constance
Fordyce
Wynot
St James
Bow Valley
Obert
Maskell
Newcastle
Sparta
Hartington
Center
Bloomfield
Verdigre
Ponca
Winnetoon
Bazile Mills
Wausa
Coleridge
Martinsburg
Creighton
Magnet
Laurel
Waterbury
Willis
Jackson
Belden
Dixon
Allen
Concord
McLean
Randolph
Plainview
Royal
Brunswick
Osmond
Sholes
Hubbard
Foster
Carroll
Wakefield
Emerson
Willowdale

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INTRODUCTION

As required by Nebraska Revised Statute #46-673.01 (Cum. Supp., 1984), the Lewis and Clark Natural Resources District has prepared this groundwater management plan based on the best currently available information.

The format for this plan follows the "Handbook on Preparation of Groundwater Management Plan" distributed by the University of Nebraska Lincoln, Conservation and Survey Division, November 19, 1984. The District has attempted to assemble technical information specific to its area in accordance with statute requirements. Based on that data, the directors have determined policy relating to future management actions for the groundwater goals and objectives of the District. Public input was sought throughout the process by media publicity, task force committee meetings, discussion at NRD Board meetings, and an advertised public meeting on the Groundwater Plan.

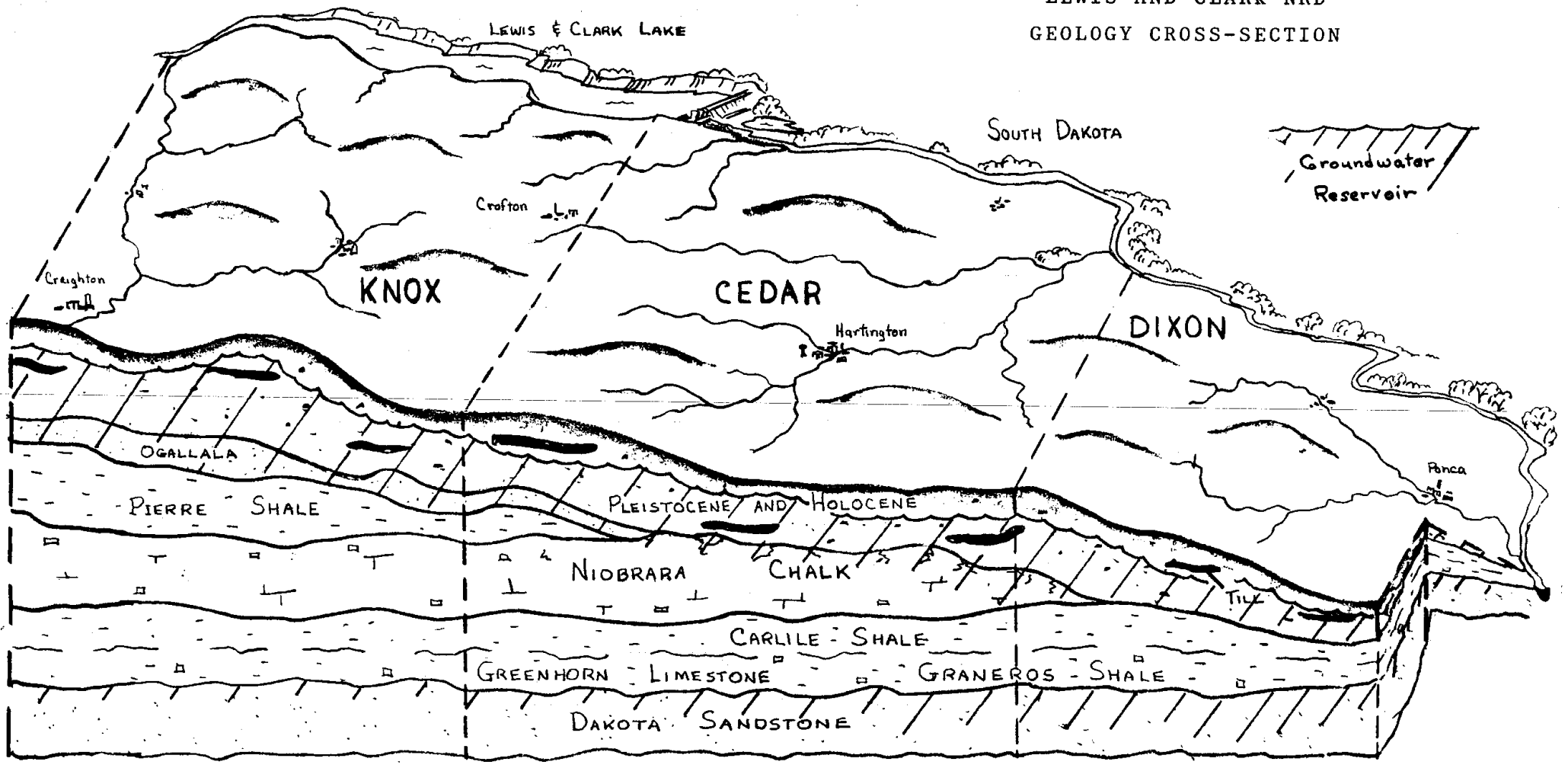
By the general nature of the information available, this report is not intended as a specific reference for individual situations occuring within the District. Rather it is intended as a concise basic document indicating the status of groundwater in the area and stating in general terms what policy goals and objectives should be considered in managing that resource.

This information was compiled by NRD Manager Tom Moser and prepared by Administrative Secretary Marilyn Schumacher. Following is a list of the Board of Directors.

LEWIS AND CLARK NRD DIRECTORS

Eugene Schroeder	William Walton
James Wortmann	Lawrence Zavadil
Allen Heine	John Thoene Jr.
Don Hart	Mark Fehringer
Ray Dykeman	John Fleming
Randall Patefield	Milo Johnson
Lou E. Benscoter	Richard Grosvenor
Dale Jackson	Harold George
Roman Kramer	

LEWIS AND CLARK NRD
GEOLOGY CROSS-SECTION



Map #1 Representative Illustration of Water Bearing Aquifers
(not to scale)

TECHNICAL ASPECTS OF GROUNDWATER IN THE LEWIS AND CLARK NATURAL RESOURCES DISTRICT

This section of the plan includes a review of known facts and circumstances relating to groundwater resources of the Lewis and Clark NRD. Following are descriptions of the groundwater reservoir, other water in the management area and water uses. Certain references will be given throughout the document and further information can be obtained by consulting those publications. This information has been condensed to pertain specifically to the Lewis and Clark NRD.

DESCRIPTION OF GROUNDWATER RESERVOIR I. Geographic and Stratigraphic Dimensions

A groundwater reservoir is an aquifer or combination of aquifers being used as a source of water. An aquifer is defined as a water-bearing layer of rock or sediment capable of yielding supplies of water. Groundwater reservoirs need to be described geographically to define the extent of surface area covering a reservoir and stratigraphically to give a vertical indication of thickness and composition of the unit.

In order to give an accurate picture of geology for the District (Knox, Cedar, and Dixon Counties), the history of the area needs to be reviewed from the depths up to the surface material. (ref IANR Educational Circular #6) The oldest subsurface rock in the region is Pre-Cambrian age found at the shallowest depth at about 900 feet below land surface in northeastern Dixon County. Since it last saw the light of day 600 million years ago, the Pre-Cambrian rock of the midcontinent of North America has been covered by sea many times. Left behind are the marine and stream deposited formations that make up the bedrock part of our complex aquifer system. (Map 1: "Illustrated Geology Cross Section" and Table 1: USGS #81-58).

Of these marine and stream deposits laid down in Paleozoic and Mesozoic times, only the upper water bearing Cretaceous formations are sufficiently water-rich and near the ground surface to be of concern and interest as aquifers of the Lewis and Clark Natural Resources District. The lowest formation penetrated by wells is the Dakota Group Sandstone, which was deposited in a shallow sea and adjacent coastal plain that connected the Gulf of Mexico to the Arctic Ocean and separated the continent. Above it is the Graneros Shale, a succession of mud layers carried by wind and streams draining from the continent to the east, and then the Greenhorn Limestone which contains more Calcareous deposits derived from algae and shell structures from marine organisms. Above this is the Carlile Shale which thins out from west to east in the District and ends in Dixon County. None of these formations is considered an important source of water for the District with the exception of the Dakota formation.

The next formation deposited was the Niobrara Formation, a chalky marine shale which outcrops along Lewis and Clark Lake and extends eastward throughout most of Cedar County and into Dixon County. Above the Niobrara Formation is the Pierre Shale (not a source of supply for wells) which extends under most of Knox County into parts of Cedar County. These bedrock formations were exposed to weathering and erosion in Tertiary time, 70 million years ago, when the Missouri River flowed north east across North Dakota to Hudson Bay and before the glaciers invaded the midwest. At present The Niobrara and Pierre formations are exposed to some extent in the Missouri

TABLE I

Table 1.--Generalized section of geologic formations and their water-bearing properties
(Modified from Simpson, 1960)

Erathem	System	Series	Formation	Lithology	Water Supply
Cenozoic	Quaternary	Holocene		Alluvial deposits	Principal source of water supply to wells, reported yields range from 550 to 1,500 gal/min; also transmits water to recharge other aquifers.
		Pleistocene		Sand and gravel deposits interbedded with clayey till.	
	Tertiary	Miocene	Ogallala Formation	Sand, silty clay, interbedded with a little volcanic ash and orthoquartzite.	Not a known source of water supply; may yield water to some domestic wells.
Mesozoic	Cretaceous	Upper Cretaceous	Pierre Shale	Shale and claystone, interbedded with thin bentonite layers, marl and sand; fissile to thin bedded, soft, weak.	Not a source of water supply to wells.
			Niobrara Formation	Argillaceous limestone, chalky, medium bluish-gray weathering to dark yellowish-orange; soft, sub-firm, highly fractured in places.	Significant source of water supply to wells through secondary porosity. Reported yields range from 360 to 900 gal/min.
			Carlile Shale	Moderate gray calcareous shale, fissile, soft, weak; interbedded with clayey siltstone.	Not a source of water supply to wells.
			Greenhorn Limestone	Light to medium dark gray limestone, interbedded with argillaceous limestone, marl, calcareous shale, and two very thin layers of bentonite.	Do.
			Graneros Shale	Medium to dark gray shale, fissile, soft, weak; interbedded with thin layers of silt and sand in lower part. Few scattered thin layers of bentonite material.	Do.
		Lower Cretaceous	Dakota Formation	Sandstone, yellowish white in color, cemented in part by calcium carbonate interbedded with medium to dark gray claystone and shale; numerous thin layers of black carbonaceous material.	Significant source of water supply to domestic and stock wells. Irrigation wells possible. Potential yields may be as much as 600 gal/min.
Paleozoic, undifferentiated				Predominantly limestones and dolomites, but some thin sandstone and shale beds.	Not used as a source of water in study area.
Precambrian			Sioux Quartzite	Orthoquartzite, grayish-orange pink, fine to coarse-grained.	Not a source of water supply to wells.

Source--USGS #81-58

River Bluffs area from east to west across the NRD. Where the Pierre shale is close to the surface in areas of northern Knox County, springs appear and large slumps have occurred causing massive land slides and sometimes moving trees and roads. Besides being visible on the Lake shores, the Niobrara chalk can also be seen in tilled fields in northern Cedar County where it shows through as a yellowish chalky subsoil when erosion has taken topsoil away. Further east in Dixon County, the Carlile Shale and Greenhorn limestone can be seen at the Missouri River landing as Ponca State Park.

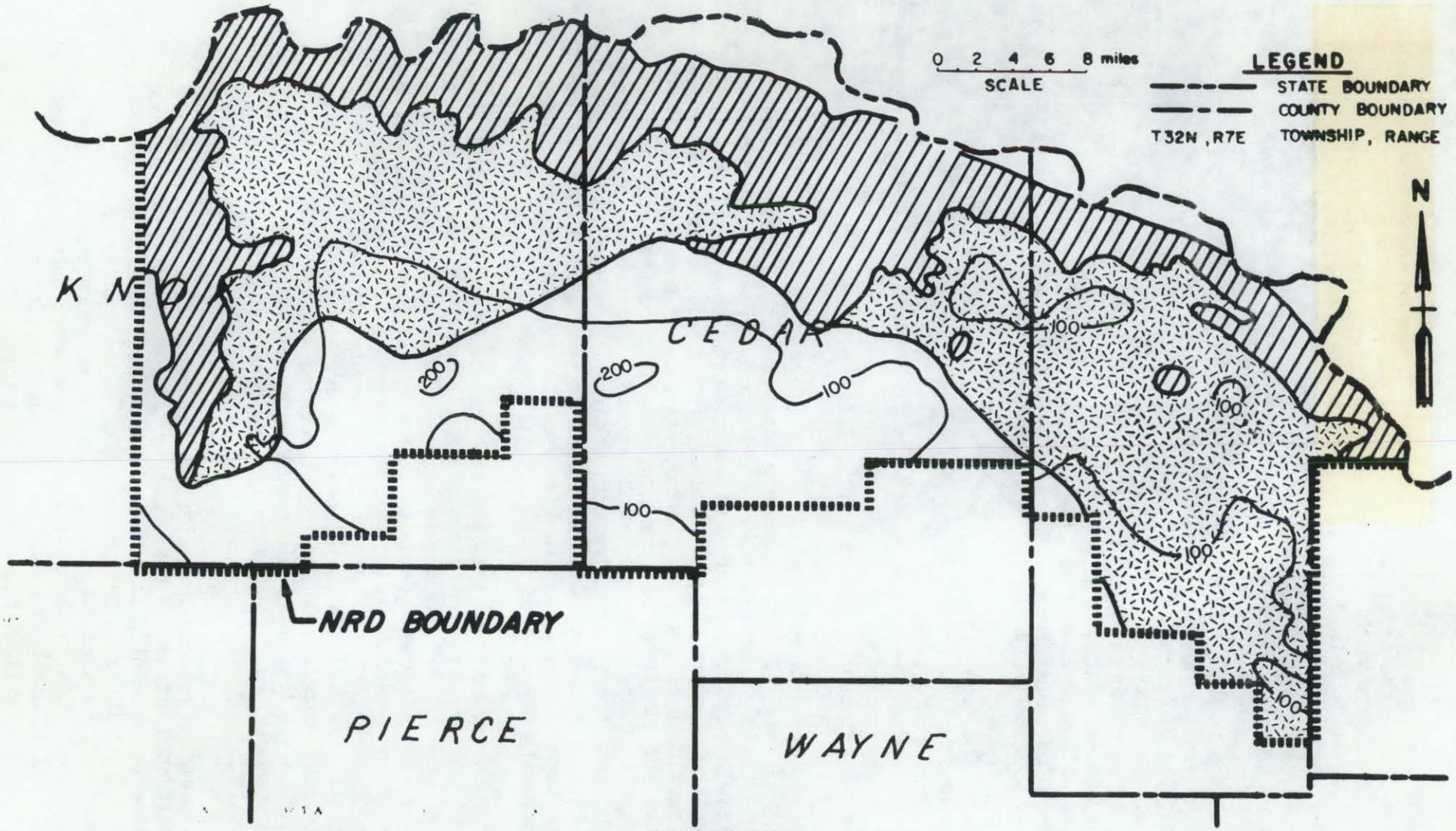
drops out

Niobrara Chalk formation outcropping along Missouri River bluffs area. Where fractures occur in this formation and it is shallow to the surface, good quality water can be found.

Above these formations of bedrock lie the principal aquifers of the District which came in with the Ice Age and are defined geologically as the "Pleistocene or Holocene deposits". They consist of sand, gravel, till (powderized rock), and younger stream and wind deposits, and constitute the principal source of water supply to wells. They were deposited by the glaciers and consisted of great loads of unstratified debris made up of particles of clay, silt, sand, gravel, and boulders. As the Wisconsin ice sheet melted, sand and gravels were deposited on and around the till and much of it was covered by wind deposited loess blown off of bare uplands and intermittent stream bottoms. Near the mouth of the Niobrara River, the Missouri River was shifted to its present course, forming a well developed pattern of drywash tributaries and streams draining the bluffs and leaving eventually the surface of this present age.

The groundwater areas in the District can broadly be described as primarily within the Northeast Nebraska glacial drift groundwater region but extending into the Missouri Valley lowlands. The primary aquifers supplying water are the sand and gravel deposits of the Pleistocene and Holocene age and the Dakota and Niobrara sedimentary formations of Cretaceous Age. While the sand and gravel deposits, when thick, hold water of variable quantity and quality for all uses, that in the Niobrara is even less reliable because it is generally less permeable unless in a fractured state. The Dakota is mostly higher in salinity and would require more careful management by users, but is used commonly, near the Missouri River as a source for artesian "flowing" wells.

The base of the principal aquifer in the District is defined as the top of the consolidated cretaceous bedrock discussed previously and the lower limit of those water holding materials which comprise the major groundwater reservoir. In this District the principal or major aquifer consists of the unconsolidated materials of Plestocene (found throughout the NRD) and Holocene Age (found usually along streams). The water saturated layer includes till, silt, and clay which are non water-yielding and sand and gravel which are water yielding. The Ogallala formation is only present in thin and eroded areas that disappear eastward across the NRD in parts of



EXPLANATION

100

Line of equal thickness
Contour interval 100 feet

Principal aquifer absent or very thin

Principle aquifer composed mostly of fine grained material, primarily till

MAP #2 - Thickness of Aquifer of the Lewis & Clark NRD

Knox and Cedar County and is in hydrologic connection with the Pleistocene. For purposes of this report, Ogallala sediments will be included with the principal aquifer. The Niobrara chalky shale is of secondary importance because it is a good supply only in the upper layers where fractures allow permeability and where it is near the surface (northern Cedar County). It is not found extensively in Dixon County and is blocked from recharge in Knox County by the Pierre Shale. The Dakota can best be described as the aquifer of last resort, but in northeastern Dixon County is the only source available when shallower aquifers are lacking.

II. Transmissivity and Saturated Thickness

By comparing configurations of the aquifer base with average water tables (1979) we can arrive at a map showing thickness of the principal Pleistocene-Holocene aquifer (map #2). Although the map shows the thickness in contour intervals of 100 feet, there is enough information to generalize on depth of the aquifer. It is interesting to note that the entire Missouri bluff area running the full length of the district has an aquifer that has little or no saturated thickness. This area extends southward along the Bazile Creek drainage and the lower Bow Creek drainage nearly to Hartington. Much of the area beyond that is additionally restricted as an aquifer because of the presence of fine grained material, primarily till; but the rest of the District has good potentially saturated thickness.

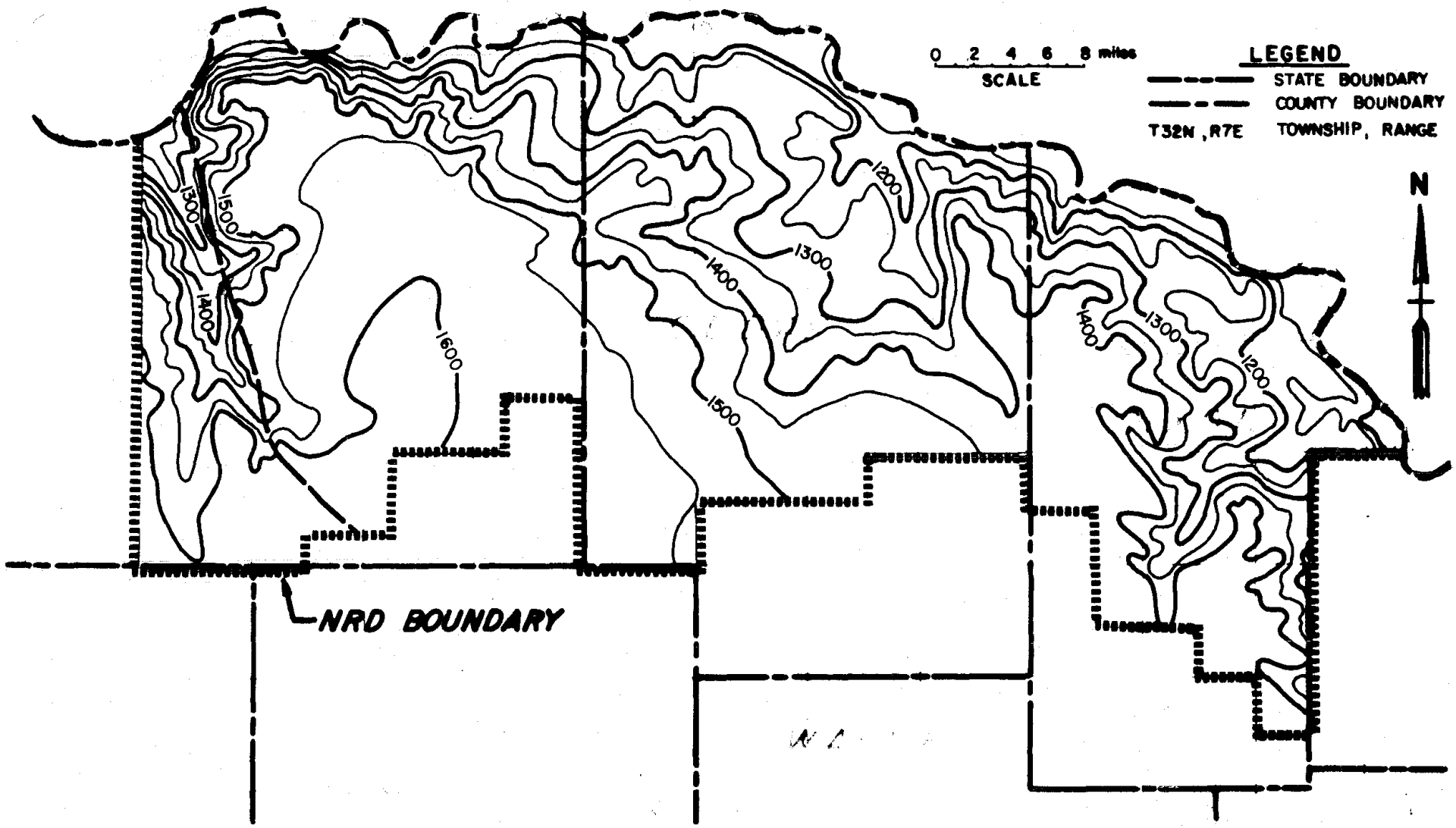
The majority of the principal aquifer is generally composed of both coarse grained material, primarily sand and gravel, and fine grained material (till, silt, and clay) and is up to 100 feet thick. Isolated spots over 100 feet deep are found in Dixon County and the entire area roughly south of a line from Bloomfield to Hartington where the District has the most groundwater use and development at present. A spot near Bloomfield and one near Pleasant Valley show a thickness over 200 feet deep. All these areas have variable thickness of porous material within the aquifer, and are not necessarily the areas of greatest availability of water. In northeast Nebraska, considerable portions of surface soils and the principal aquifer are fine grained material that yield water slowly and impede the migrations of groundwater.

The aquifer material and water table slope affect the low transmissivity or rate at which water is able to move through an aquifer. Movement of groundwater along a flow line probably is no more than 3 to 4 feet per day and in total volume has changed little from 100 years ago. Transmissivity values express the aquifers total permeability in relation to the saturated thickness and can be used to make estimates of well yield, which are generally low in this particular area. Groundwater level contours show that groundwater movement in the district runs generally east or northeast toward the Missouri River (see Map #3).

The transmissivity map (Map #4) for the District shows a large area having less than 20,000 gallons per day per foot transmissivity with the remainder showing 20,000 to 100,000. Generally those areas with values less than 20,000 gallons per day per foot are incapable of well yields sufficient for irrigation. In such areas aquifer transmissivity would seem to limit groundwater irrigation development potential. Irrigation well development has substantiated this (Registered Wells Map #5) so that a comparison of transmissivity with well development shows the limited area with potential for irrigation from the principal aquifer.

III. Depth to Groundwater Level

The distance from the ground surface to the water level is the depth to groundwater. This distance varies with season and location across the



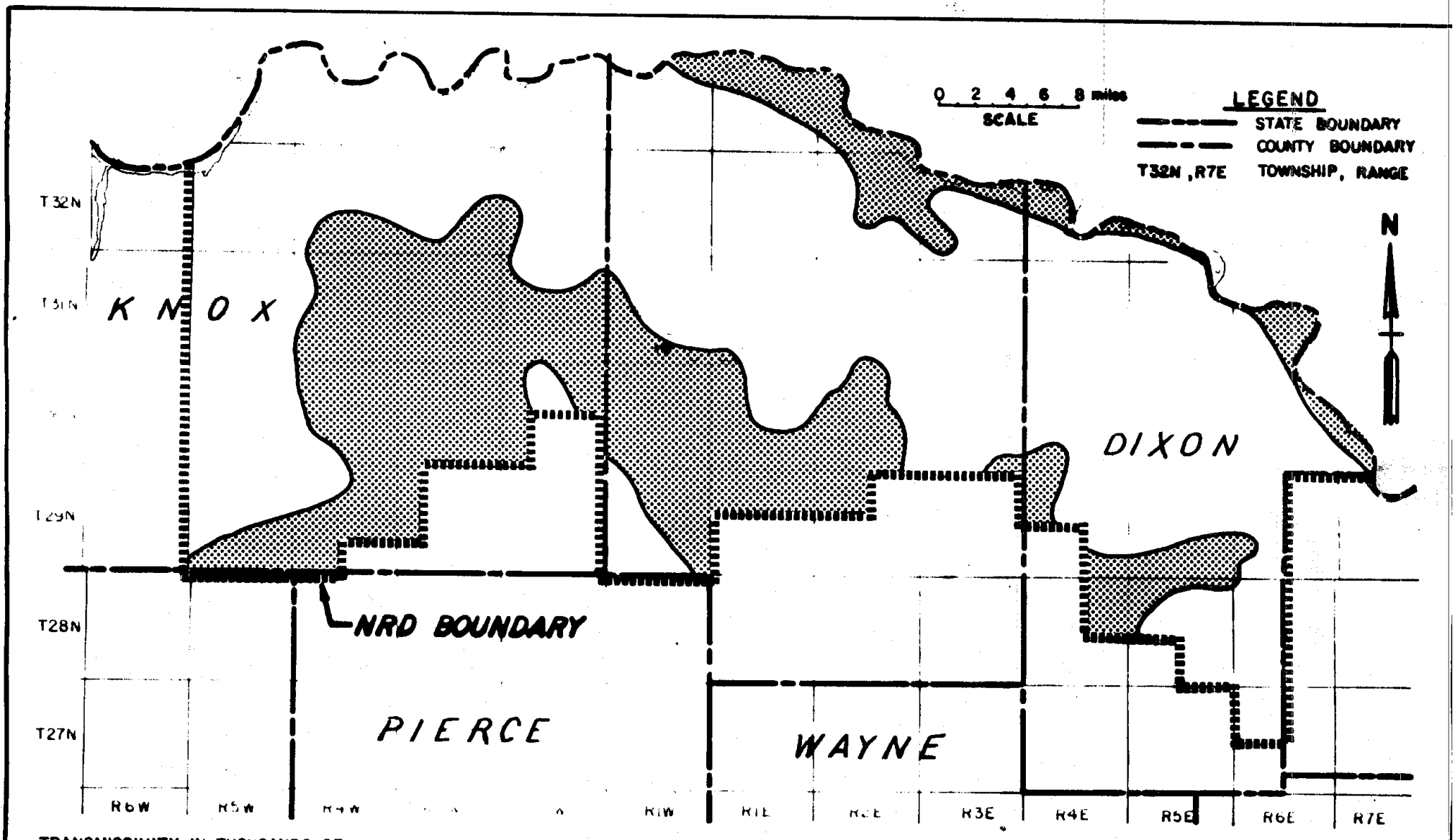
Explanation

—1700—

Water-table contours

Contour interval is 50 feet. Datum is mean sea level. Contours east of the dashed line represent only the level of water that might be found in shallow wells.

MAP #3 WATER TABLE CONFIGURATION OF LEWIS & CLARK NRD

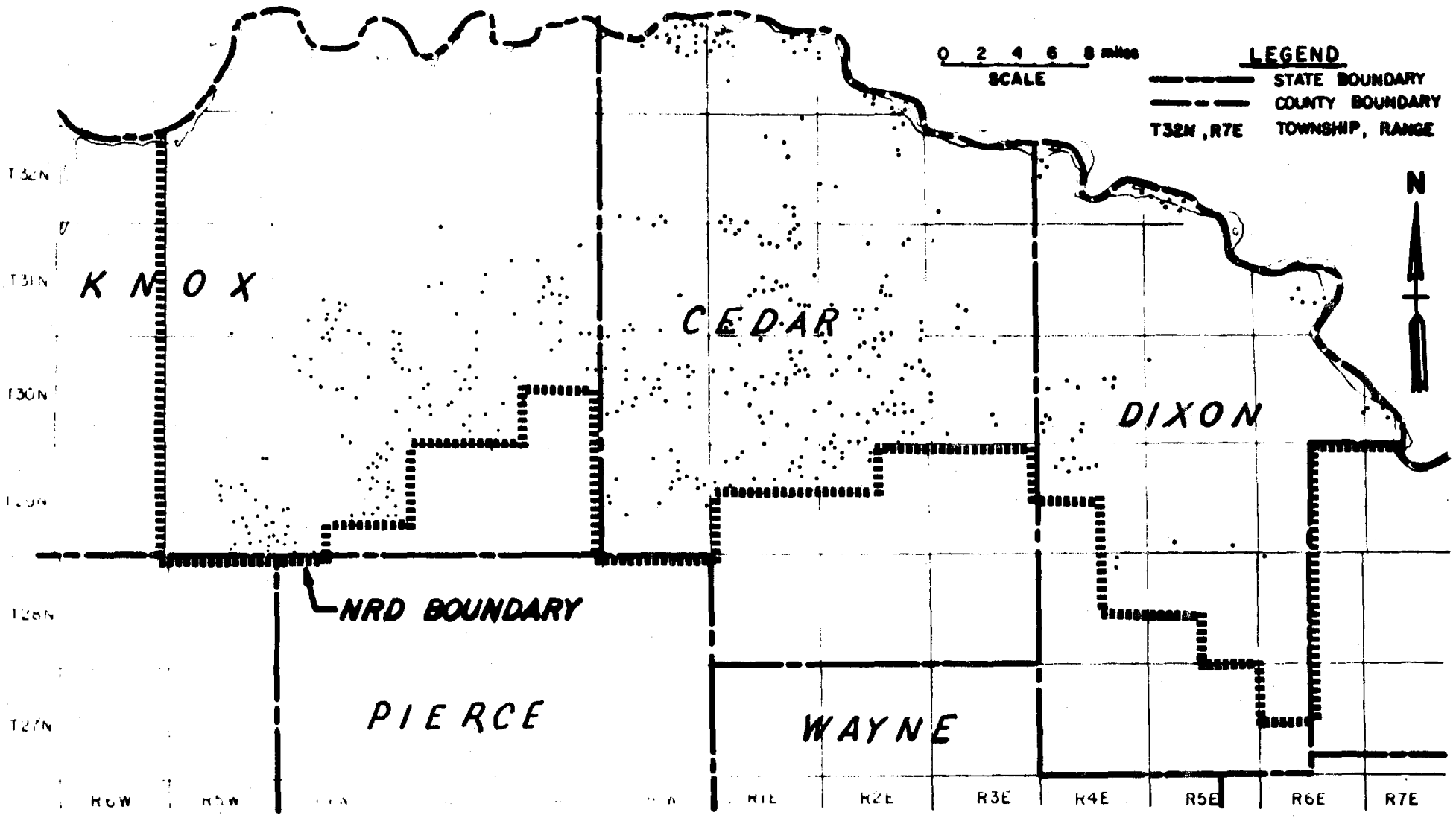


TRANSMISSIVITY IN THOUSANDS OF GALLONS PER DAY, PER FEET

0 - 20

20 - 100

MAP # 4 - Transmissivity of the Principle Aquifer in the Lewis & Clark NRD — A function of aquifer thickness and permeability, transmissivity estimates provide an indication of the productivity of an aquifer.



MAP # 5 Registered Irrigation Wells thru 12/31/84 in the Lewis & Clark NRD

District. A depth to water map by necessity must be very general (Map #6), but we can determine that in parts of northeastern Knox County and northern Cedar County we should be able to locate water at less than 50 foot depth in the Niobrara formation or Holocene sand and gravel deposits along the major streams and tributaries. Otherwise most water tables are found in the Pleistocene over a range of 50 to 200 feet deep. An area starting in the Lindy area and running southeast toward Wausa and into Cedar County has water tables of over 200 feet below the ground surface (ref Nebraska Groundwater Atlas, 1981). Throughout eastern Nebraska shallow "perched water tables" are common because of less permeable glacial till and these "pockets" of water can cause some shallower wells to have unexpectedly high water levels.

In describing the depth to groundwater for the aquifers of the District we refer to information from the Crofton Unit Geohydrologic Study, USGS, 1981. "The Pleistocene and Holocene sand and gravel deposits are thin or absent in much of the northern parts of the area, but are the source of water from wells along streams or the Missouri River and also in the area south of Hartington in Cedar County. Average water levels in the Pleistocene during 1978 ranged from 6 feet to 165 feet while saturated thickness was about 77 feet. Yields from irrigation wells ranged from 550 to 1500 gallons per minute".

The Niobrara formation underlies much of the District, and is characterized by a medium bluish-gray chalk or chalky shale that weathers to dark orange-yellowish. Many of the local people refer to it as "shale" because of its color. This formation sometimes yields sufficient good quality water for irrigation wells especially in Northern Cedar County, because solution openings and fractures store and transmit groundwater. Depths to water in the Niobrara wells range from 2 feet to 45 feet in 1978, in the area covered by the USGS study.

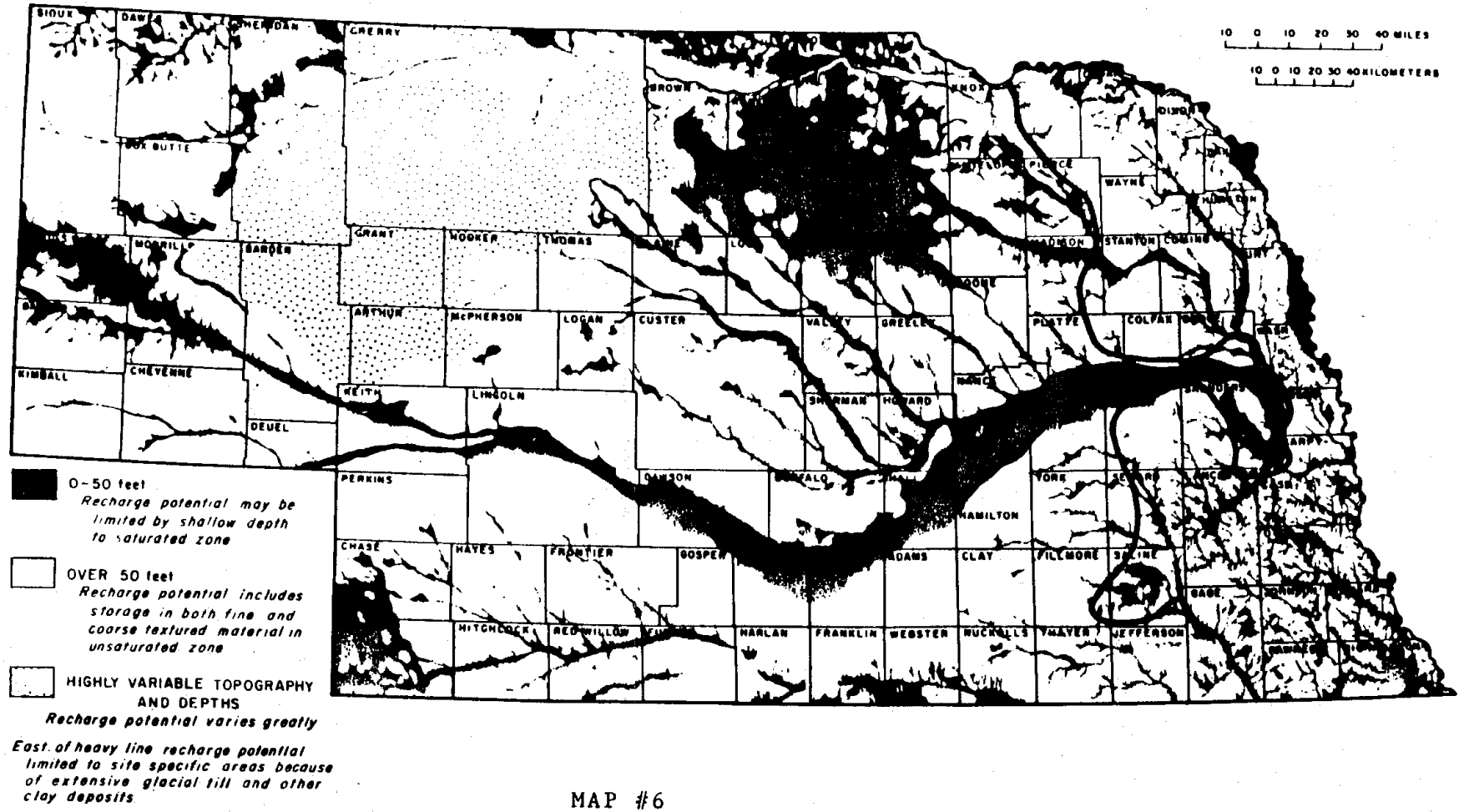
The Dakota formation underlies the shale of the Carlile, Greenhorn, and Granerous formations. It is composed mostly of fine to coarse grained yellowish white sandstone with some gray claystone and shale. It has been developed in scattered locations for domestic and livestock use and wells are generally very deep. Because of the formations confining pressure however, water rises to within less than 260 feet of the ground surface and vary to some free-flowing artesian wells.

The NRD monitor program measures static water levels twice a year at 30 sites throughout the NRD. Water levels vary from 4 feet to 290 feet in wells measured across the NRD and average 90 feet. Records kept since 1975 indicate water tables have remained fairly constant in the District. These measurements are part of a state-wide observation well data collection system as part of a cooperative program with United States Geological Survey and the Conservation and Survey Division. (ref. Groundwater Levels in Nebr., 1984). Selected examples of the well monitor hydrographs provided by U.S. Geological Survey show water level trends in some wells on Table II.

As stated earlier in this plan, site specific estimation of localized depth to Groundwater is unreliable due to the presence of local perched water tables. This plan can only present generalized information about the range of depths in the District.

IV. Recharge Characteristics and Rates

Aquifers are recharged by precipitation, runoff, and surface water



MAP #6

Generalized Depth to Water - This map was developed from a depth to water map which was produced by CSD for the NRC policy issue study on groundwater reservoir management (1982).

infiltration. The factors affecting recharge are depth to groundwater, precipitation amounts, land slope, soil types, permeability of the subsoil and storage potential.

Natural recharge takes place through precipitation falling on the land or percolating through porous soils and valley streambeds, following concentrated runoff. Well monitor levels indicate that essentially no recharge results from the Missouri River and likewise, Lewis and Clark Lake does not contribute to the natural recharge of the District because groundwater levels slope downhill towards the River.

The Pleistocene and Holocene deposits receive their recharge from precipitation. Recharge to the Niobrara formation likewise is by percolation through the overlying permeable material. The glacial till in this part of Nebraska is of low permeability and in places causes perched water tables by intercepting some recharge.

On the average, a predictable percentage of annual precipitation becomes groundwater recharge. Two important variables affecting groundwater recharge are soil and topography. By comparing the average annual precipitation (24" to 26") with typical topographic regions, an estimate of recharge can be calculated for the District. The topographic region best classifying this district is the "rolling hills" which has a recharge percentage of 1 to 5%. This would indicate that under average conditions .25 to 1.3 inches or about an inch or our annual fainfall acts as recharge in the District. Along the Missouri River Valley, the annual recharge activity would be higher because of the difference in topography. (reference Groundwater Management Plan Handbook)

The potential for accepting more water into the aquifer is moderate to excellent with some limits due to underlying glacial till. Although adequate storage potential is sometimes limited and land slope increases runoff losses, the soil structures and especially sand and gravel materials, provide generally good permeability for water absorption ranging from 1 inch per hour in clay soils to 10 inches per hour in loamy sands (ref. USGS paper #2245)

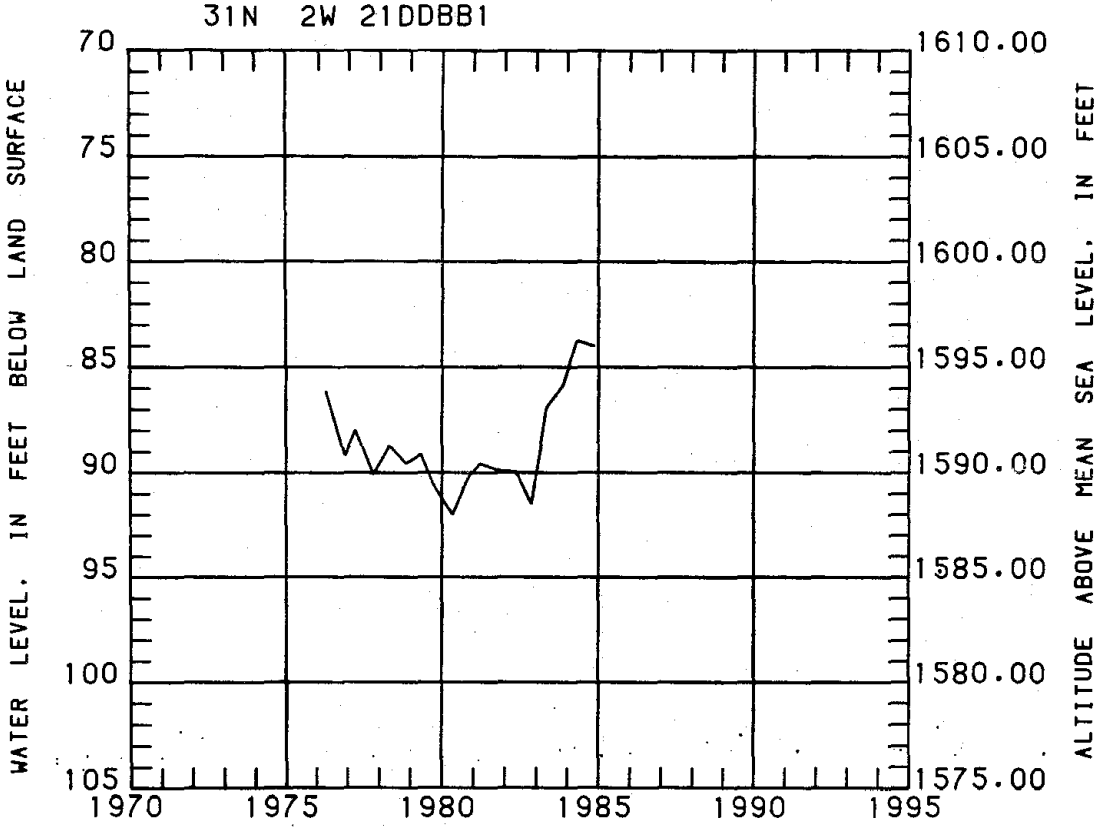
Because of the soil associations of particular parts of the NRD, recharge potential would be greater in areas where surface and subsurface soil is more coarse or sandy. From USGS paper #2222, (Hydrology Characteristics); those highly permeable soil associations would include: Bazile-Paka Thurman, Moody-Thurman, O'Neil-Meadin-Jansen, Simeon-Meadin-Betts, and Thurman-Boelur-Nora (Map #9). Properties of individual soil types are described in detail in local county soil surveys. These areas bear watching because they have excessive drainage capability allowing permeability from 5 to 14 inches per hour and have a high potential for groundwater pollution by agrichemicals or other contaminents. Other areas that might be likewise affected are soils developed over weathered Niobrara formation.

Consideration on Artificial recharge has been discussed in the District as part of the Crofton Unit Appraisal Report (Bureau of Reclamation 1979). Recharge from construction of such a project from Lewis and Clark Lake was estimated at 1,000 acre feet per month, should the project ever be built.

TABLE II

KNOX COUNTY

31N 2W 21DDBB1



CEDAR COUNTY

30N 1W 30ADBB1

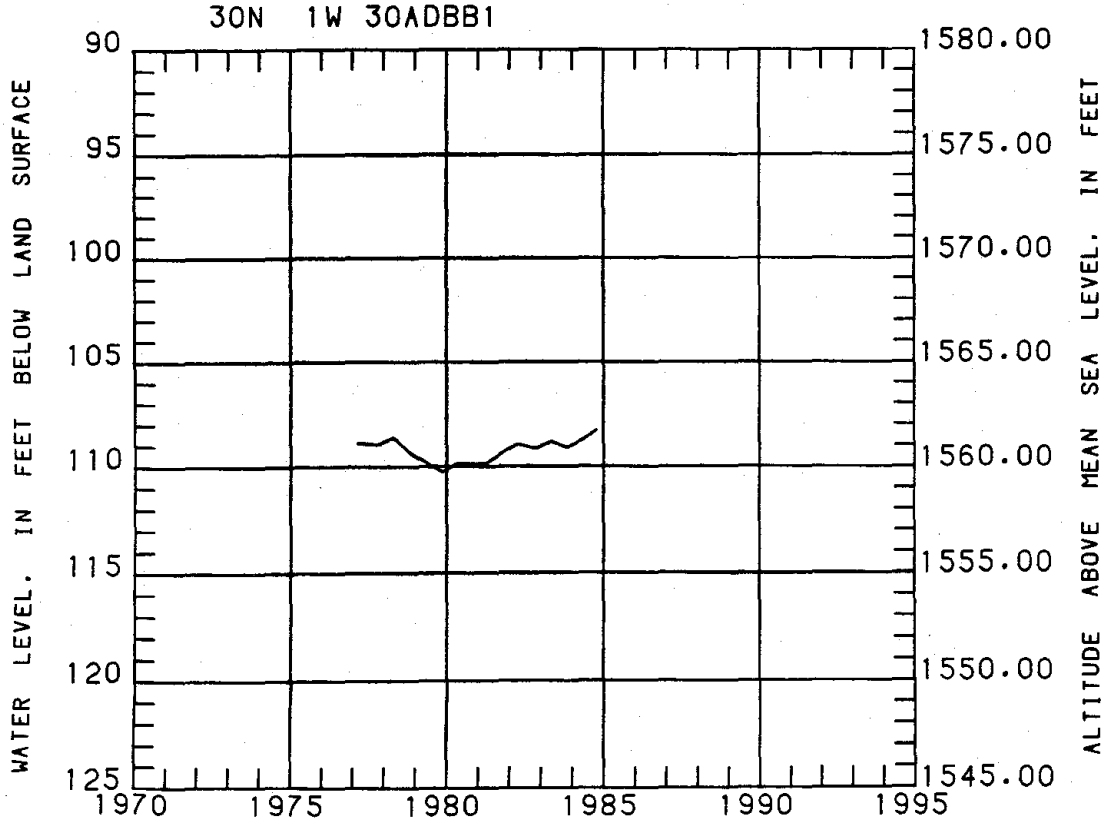


TABLE II

CEDAR COUNTY

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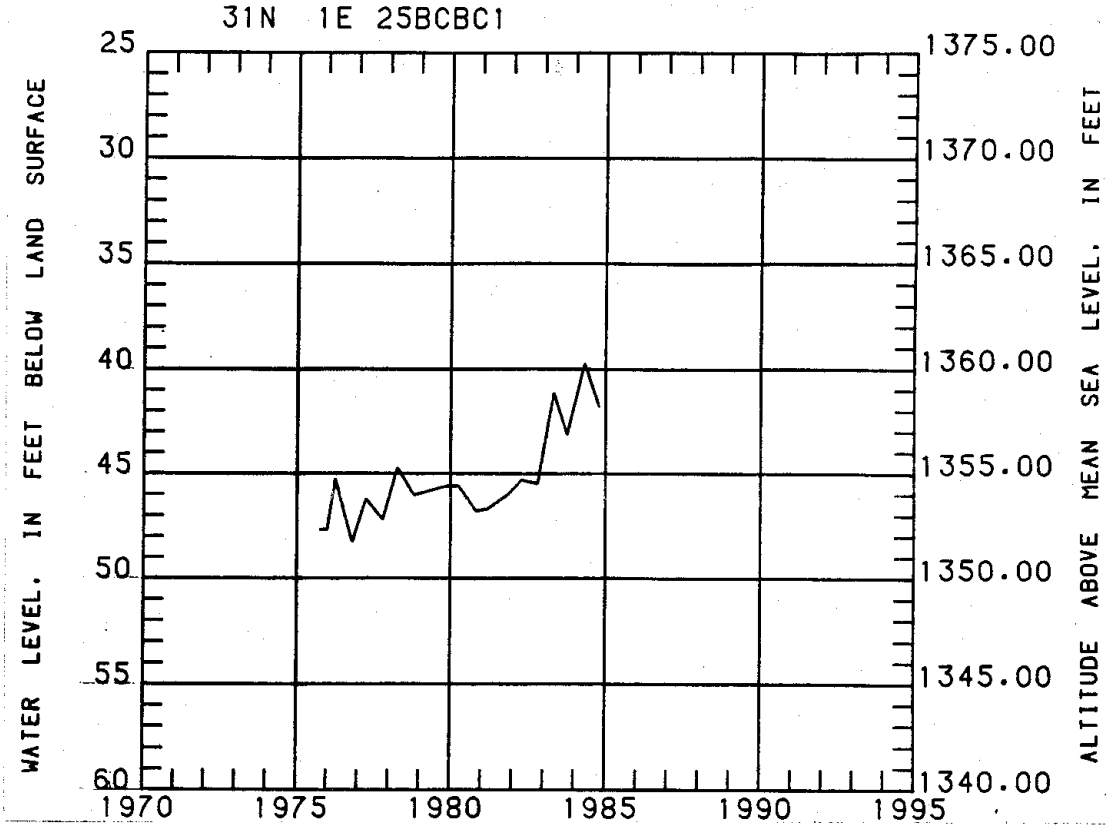


DIXON COUNTY

29N 4E 8ACBA1

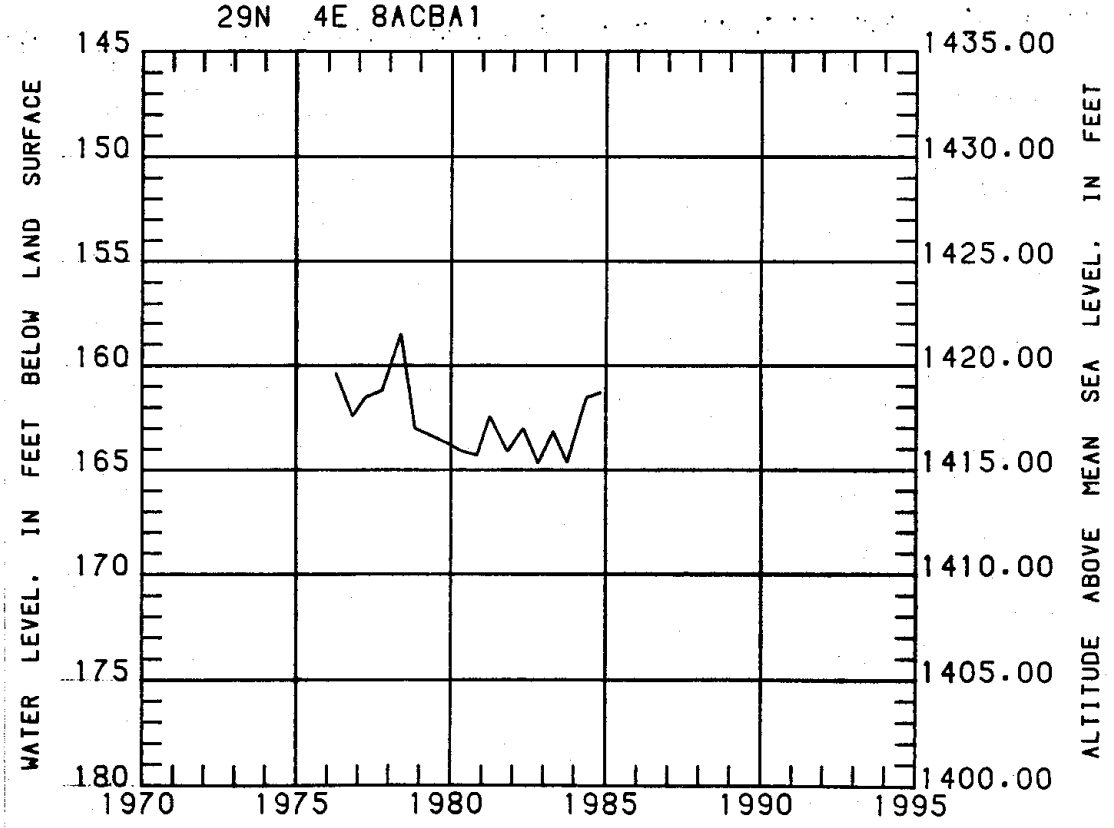


TABLE III

CHEMICALS OF DISTRICT CONCERN

CHEMICAL	STANDARD OR LIMIT (mg. per liter)	SIGNIFICANCE
Calcium		Imparts hardness to water, desirable with sodium in irrigation
Magnesium		Significantly affects hardness, desirable with sodium in irrigation
Sodium		May be harmful if on low sodium diet can be undesirable in irrigation eventually causes soil swelling and reduces tillability
Potassium		Essential in animal nutrition, may or may not be soluble
Alkalinity		Bicarbonate, has capacity to neutralize acidity
Sulfate	250	Contributes to salinity in irrigation, may have laxative affect
Chloride	250	Contributes to salinity in irrigation, causes salty taste in water
Silica		Found in sand aquifers, plant nutrients, contributes to boiler scale
Nitrate-Nitrogen	10	Health hazard for infants, common human pollution result
Iron	.3	Stains laundry and fixtures, causes discoloration and taste
Manganese	.05	stains laundry and fixtures, causes discoloration and taste
Selenium	.01	micronutrient, but toxic in higher concentrations
Phosphorus		essential nutrient, not likely toxic
Fluroide	1.7	beneficial to teeth in amounts of

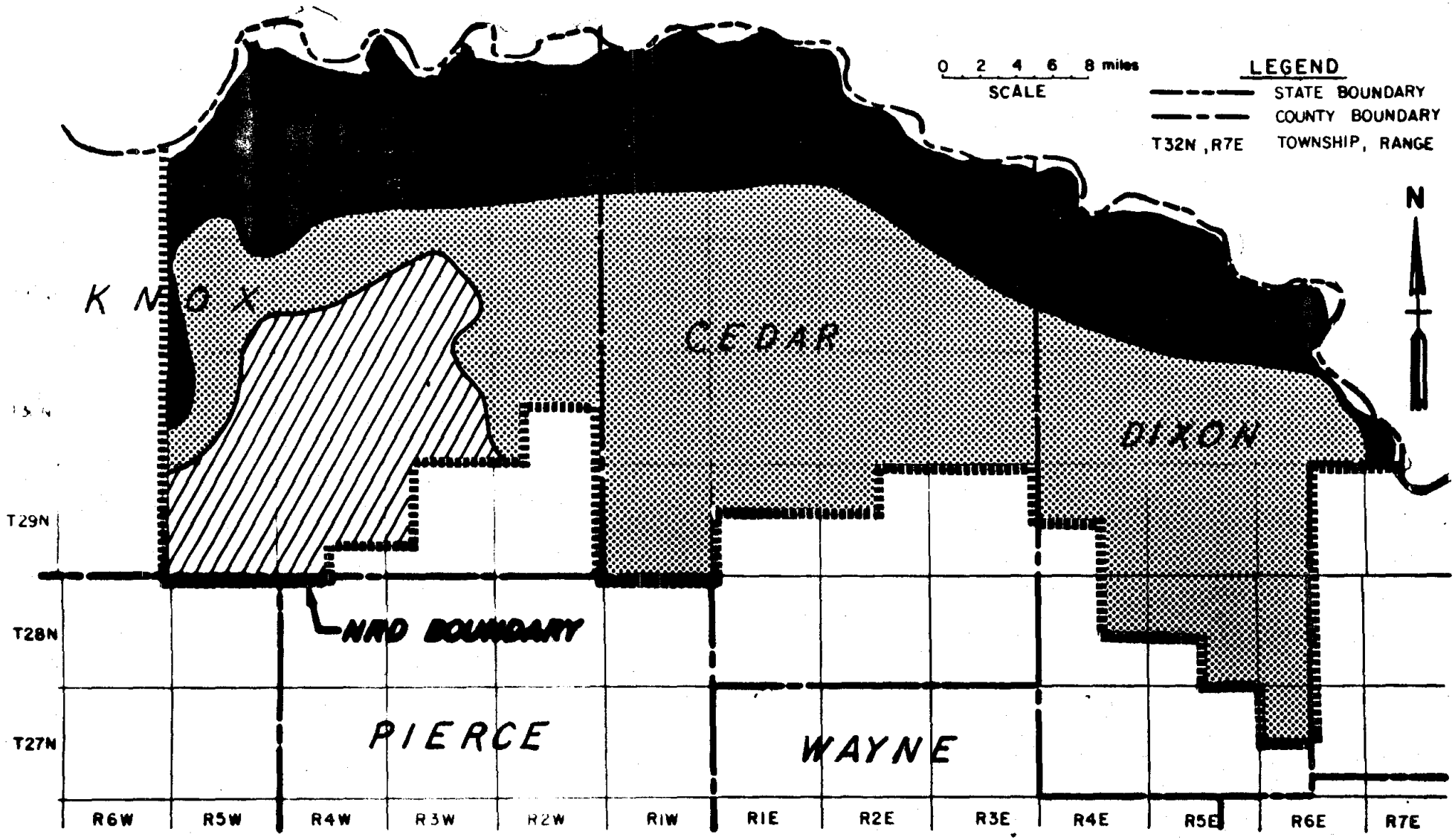
V. Groundwater Quality

The Lewis and Clark NRD considers the quality of our groundwater its most serious concern. Water quality "standards" are recommended safe limits for some chemical constituents and desirable limits for others. Standards for some constituents differ depending on intended use. Precipitation as it runs off or percolates into the ground is altered by reaction with mineral and organic substances in the soil and vegetation to form different characteristics affecting water quality. The more permeable the soil, the less the opportunity for chemical reaction and the better the quality of the infiltrated water. This report will review the major chemicals found in the groundwater reservoir, safe levels and significance for each, and indicate the concerns that need be addressed.

Most groundwater in the principal aquifer is of good to excellent quality. Generally, water low in chemical content or "total dissolved solids" is suitable for most uses, while very mineralized water is considered unsuitable for many uses. Amounts of total dissolved solids in this District run higher than most areas of the state, ranging from 200 to over 1,000 mg/l (see Map #7). The higher concentrations of greater than 1,000 are mostly found north of Highway #12. High concentartions of over 500 mg/l can create salinity problems harmful to irrigated crops.

The major dissolved solids are calcium, magnesium, sodium, potassium, bicarbonite or alkalinity, sulfate, chloride, and silica. This plan will also include nitrate, boron, iron, manganese, selenium, phosphorus, and fluoride.

Table III is a list of chemical properties of concern in the District (ref. USGS #2245).



Zones of concentration, milligrams per liter

201–500

501–1000

Greater than 1000

MAP # 7 – Concentration of Dissolved Solids in the Lewis & Clark NRD – This map shows areas of concentration of inorganic chemicals in groundwater. This information, as well as other groundwater quality data, is available in the CSD publication "Groundwater Quality Atlas of Nebraska".

The chemicals of chief concern to the NRD and found regularly (ref. Groundwater Quality Atlas, 1978) are: calcium and magnesium, which affect hardness, and are generally greater than 360 mg/l throughout most of the District; sodium plus potassium, which are found in concentartions of over 50 mg/l around Wausa and along the Missouri River Bluff areas; and iron and manganese, usually found concurrently and considered nontoxic but objectionable.

Within the District, known isolated point source pollution problems have arisen near Center (hydrocarbons) and near Hartington (chloride) (ref. Nebraska Water Quality Strategy, 1985).

The sodium hazard of irrigation waters is indicated by the Sodium Absorption Ratio (SAR). The SAR indicates the extent to which irrigation water will replace absorbed calcium and magnesium on soil and clay particles with sodium. Sodium absorption causes soil swelling and reduces tillability, eventually rendering soils unfit for crop production. Water with an SAR of less than 10 units is classified as low sodium hazard. Such water is suitable for irrigation on almost all soils and crops except very sodium-sensitive ones. For all groundwater in the central NRD, the sodium hazard is minimal. (ref. USGS 81-58).

Also of growing serious concern is groundwater contaminated with nitrate-nitrogen occuring at scattered locations throughout the District. Because of the hazardous side effects of methemoglobinemia, a blood disorder in infants, water having more than 10 mg/l of nitrate-nitrogen is considered a serious threat to rural and municipal supplies. The effects of nitrate-nitrogen on livestock is also of concern, although water containing less than 100 parts per million is normally safe (ref. Crowley Research Paper #80-2026). Contamination of groundwater is usually the result of the leaching of livestock or human wastes, fertilizer, or other agriculture chemicals.

To complicate this problem, records of testing done by the Department of Health to show the exact location where nitrate problems have occurred in the District are not publicly available, for reasons of privacy, to the individual well owners tested. General results from the testing does indicate nitrate presence, however. 1984 saw 63 samples tested in Cedar County with 28 having concentrations over 10 mg/l, Knox County had 89 samples tested with 38 having high concentrations, and Dixon County had 10 samples out of 19 that showed high nitrate. This data is inconclusive because it merly indicates sample results and cannot be separated out for the NRD, for types of wells or number of samples from the same well. Unverified reports of individual problems, are mostly found where the aquifer is being more utilized for irrigation and groundwater development in southern Cedar County and southeast Knox County. Reports have also come however, from the Lindy area and isolated farm wells at various locations.

Water tables have risen in past years in many places, causing a mixing of groundwater with contaminated recharge water that has affected shallower wells. Because concentrations vary widely with several factors, the present data does not allow us to portray zones of nitrate in groundwater. Attention needs to be given to prevention measures and better identification of existing problem areas, because methods to get rid of nitrates involve expensive and sometimes ineffective treatment or locating an alternate supply source. Results of the Hall County Report on Nitrates and Irrigation Managment show that with intensive irrigation

TABLE IV

--Chemical quality of ground water, 1978

[umhos = micromhos per centimeter at 25 degrees Celsius; mg/L - milligrams per liter; Mg/L = micrograms per liter]

Well number	Date of sample	Total depth of well (feet)	Specific conductance (umhos)	pH (units)	Hardness (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sodium adsorption ratio	Potassium, dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Solids, residue at 180° C., dissolved (mg/L)	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Boron, dissolved (ug/L as B)
Water from the Dakota Formation																
31N-1E-13DDB1	78-08-09	820	1,760	7.3	770	240	41	130	2.0	24	266	750	58	1,330	0.06	410
32N-2E-12CBC1	78-08-22	520	1,610	7.3	770	240	42	51	.8	18	83	730	55	1,320	.01	110
32N-2E-24BC1	78-07-27	288	1,510	7.5	770	240	42	42	.7	19	180	650	43	1,210	.57	160
32N-2W-15DC1	78-08-09	746	1,560	7.4	820	260	41	59	.9	17	211	690	54	1,230	.01	140
33N-2E-30BD2	78-07-27	515	1,560	7.3	830	260	44	44	.7	17	196	690	48	1,250	.13	140
33N-2W-27DAC1	78-08-09	900	1,420	7.3	780	240	44	60	.9	21	220	630	61	1,140	.36	360
Water from the Niobrara Formation																
30N-1E-14BCB1	78-08-02	105	644	7.3	330	93	23	18	.4	8.3	378	57	4.5	359	.29	80
31N-2E-22BCDD1	78-08-02	87	879	7.0	480	160	19	19	.4	6.0	474	120	8.7	592	.17	100
31N-2E-30ADA1	78-08-03	77	740	7.2	390	140	10	6.3	.1	4.5	368	100	2.8	447	.15	50
31N-1E-21CAA1	78-08-02	100	619	7.3	310	90	21	14	.3	7.5	344	61	2.8	347	.42	70
31N-1E-25BCB1	78-08-01	100	637	7.2	320	94	21	18	.4	5.4	343	75	5.3	307	.06	80
31N-1E-36BB1	78-07-26	84	739	7.5	350	100	25	21	.5	7.5	345	92	20	470	.20	60
31N-1W-4ABAD1	78-07-26	98	695	6.9	330	95	23	21	.5	10	294	140	2.1	452	.06	120
Water from both the Niobrara Formation and Pleistocene deposits																
31N-1E-4DDB1	78-08-08	104	1,650	6.7	1,000	380	19	18	.2	4.9	502	630	2.7	1,100	.27	80
32N-1E-1BBD1	78-08-08	100	1,970	6.9	1,300	420	49	29	.4	12	376	970	5.2	1,710	.70	260
32N-1E-22DCCC1	78-07-27	100	2,040	6.6	1,300	480	26	28	.3	10	642	810	6.2	1,760	.11	190
32N-1E-32CCD1	78-08-07	105	1,310	7.0	590	190	29	22	.4	9.5	445	270	5.0	640	.25	120
33N-1E-30DDD1	78-08-09	85	1,840	6.8	1,100	370	42	29	.4	12	520	680	26	1,270	.85	180

Source--USGS #81-58

TABLE IV - continued

Table 4.--Chemical quality of ground water, 1978--Continued

Well number	Date of sample	Total depth of well (feet)	Specific conductance (umhos)	pH (units)	Hardness (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sodium adsorption ratio	Potassium, dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Solids, residue at 180° C., dissolved (mg/L)	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Boron, dissolved (ug/L as B)
Water from Pleistocene or Holocene deposits																
29N-2E-3CCCC1	78-07-26	195	755	7.2	380	110	26	18	0.4	6.0	351	110	4.8	486	5.4	60
30N-3E-31ADD1	78-08-07	169	979	7.3	340	96	24	26	.6	4.8	220	41	2.2	529	49	80
30N-2E-3BBD1	78-08-22	150	589	7.3	280	81	18	15	.4	6.0	261	75	2.4	393	5.9	40
30N-2E-8CCCD1	78-08-01	117	659	7.2	340	96	25	19	.4	5.6	320	110	2.8	445	2.9	70
30N-2E-12ACC1	78-08-03	147	863	7.2	350	100	25	19	.4	4.8	221	110	3.0	512	28	60
30N-2E-27AAA1	78-07-26	188	622	7.1	300	84	21	19	.5	4.9	316	66	2.5	386	3.5	60
30N-1E-7CCD1	78-08-01	147	701	7.4	350	95	27	16	.4	15	350	100	3.8	430	1.6	100
31N-2E-1CCC1	78-08-22	60	1,390	7.1	680	210	38	18	.3	17	421	370	7.1	979	.17	140
31N-2E-2DDC1	78-08-22	35	1,165	7.2	630	200	32	22	.4	17	497	270	4.3	722	1.5	140
31N-1W-13DDD1	78-07-26	80	667	7.8	320	92	22	20	.5	5.4	347	59	6.3	435	4.4	40
31N-2W-13BCB1	78-08-09	120	1,190	7.0	610	170	46	38	.7	10	419	330	7.3	880	3.2	90
32N-2E-29BDB1	78-08-08	55	1,650	6.8	1,000	360	27	24	.3	8.1	421	670	15	1,230	2.3	130
32N-2E-32DAC1	78-08-01	65	1,910	6.7	1,200	380	67	26	.3	33	704	710	4.3	1,440	.13	680
32N-2E-32DAC2	78-08-01	100	2,620	6.7	1,700	560	70	37	.4	17	627	1,100	67	2,370	9.4	300
32N-1E-8CCD1	78-08-08	100	509	7.3	250	78	13	12	.3	2.1	262	24	2.7	314	9.3	20
32N-1E-14BAB1	78-08-22	23	1,070	7.2	580	200	20	17	.3	7.8	314	310	14	792	7.9	60
32N-1W-4BCC1	78-08-23	35	1,470	6.7	800	290	18	17	.3	9.8	456	450	3.1	986	.08	190
32N-1W-20ACBB1	78-07-26	22	894	7.4	400	120	25	23	.5	4.6	244	41	26	705	50	30
32N-2W-18ACA1	78-08-09	65	970	7.1	520	89	72	38	.7	9.8	437	120	34	645	23	110
33N-2E-34CBC1	78-08-08	65	1,220	7.3	660	170	56	72	1.2	9.4	508	370	10	777	2.1	170
33N-1E-11DCA1	78-08-08	73	1,358	7.4	630	170	49	83	1.4	12	532	340	12	901	4.1	190
33N-1E-17BBD1	78-07-27	55	1,170	7.3	610	180	39	23	.4	8.3	465	270	5.6	782	.09	120
33N-1W-10CCB1	78-08-09	54	1,146	7.1	630	200	32	27	.5	9.0	444	310	4.0	720	2.5	110

Source--USGA #81-58

TABLE V

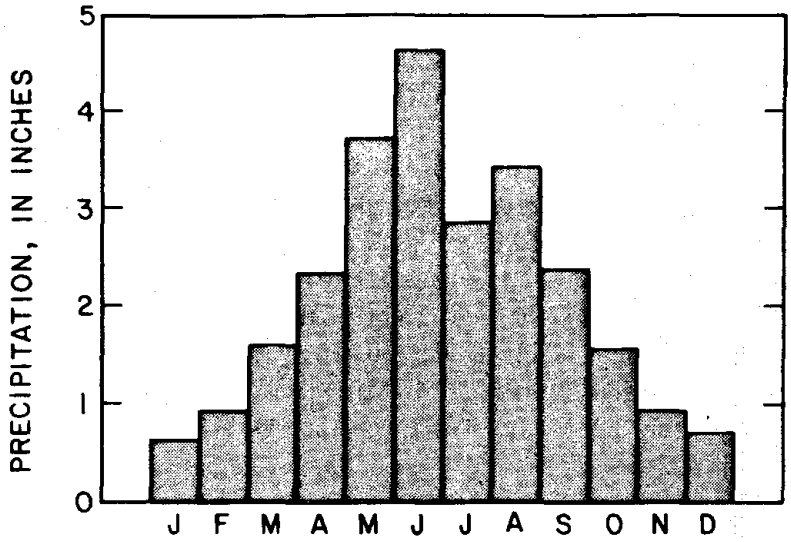
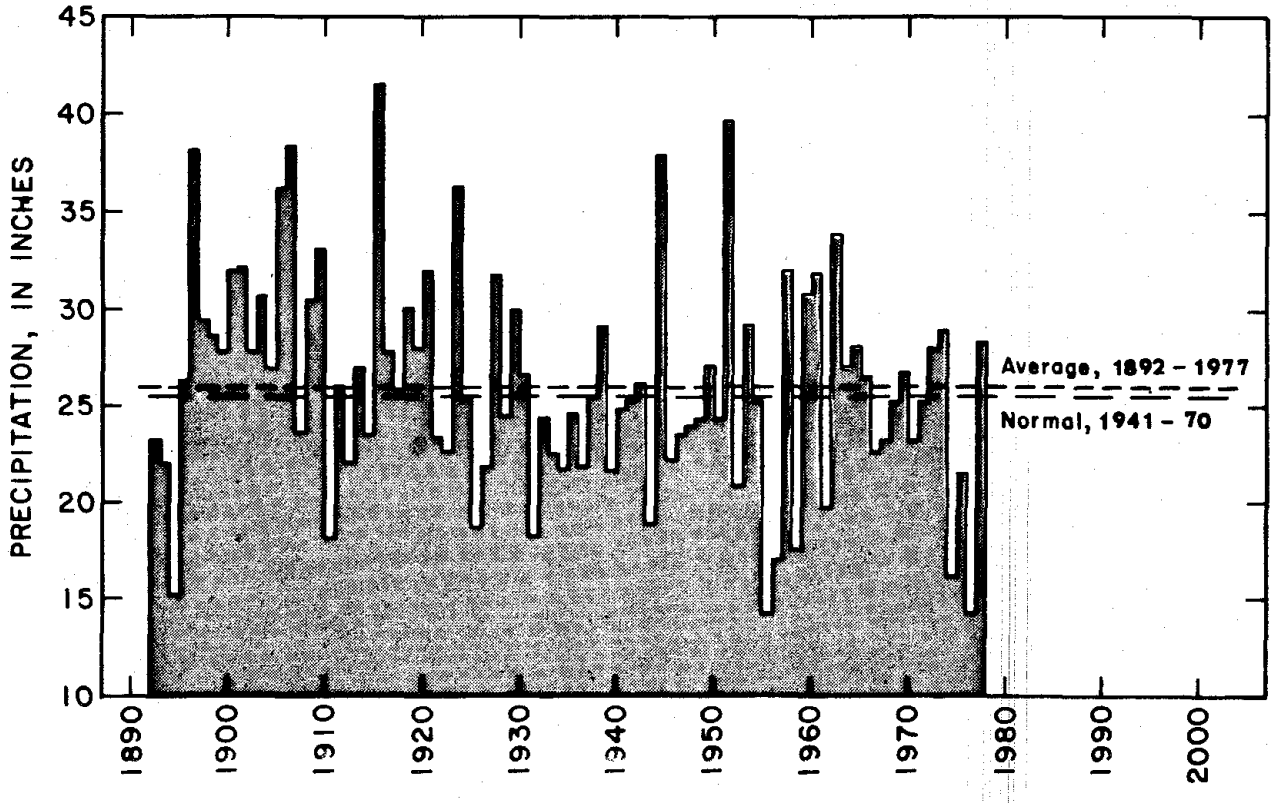


FIGURE 2.--NORMAL MONTHLY PRECIPITATION, HARTINGTON, NEBR., 1941-70.



AVERAGE ANNUAL PRECIPITATION, HARTINGTON, NEBR., 1892-1977.

Source--USGS #81-58

management (irrigation scheduling and water management) nitrate-nitrogen leaching can be minimized and possibly stabilized. Within the District the communities of Creighton, Martinsburg, and Allen have reported nitrate problems in their supplies. Although Allen has reportedly solved their problem with a new well. Creighton continues with high nitrate (11.8 mg/l as of April, 1985). In addition, samples taken by the city, of wells in the rural area of a three mile radius of Creighton, has 5 of 12 samples in March, 1985, showing over 10 mg/l with others near that mark. This area warrants concern for groundwater quality in the immediate future.

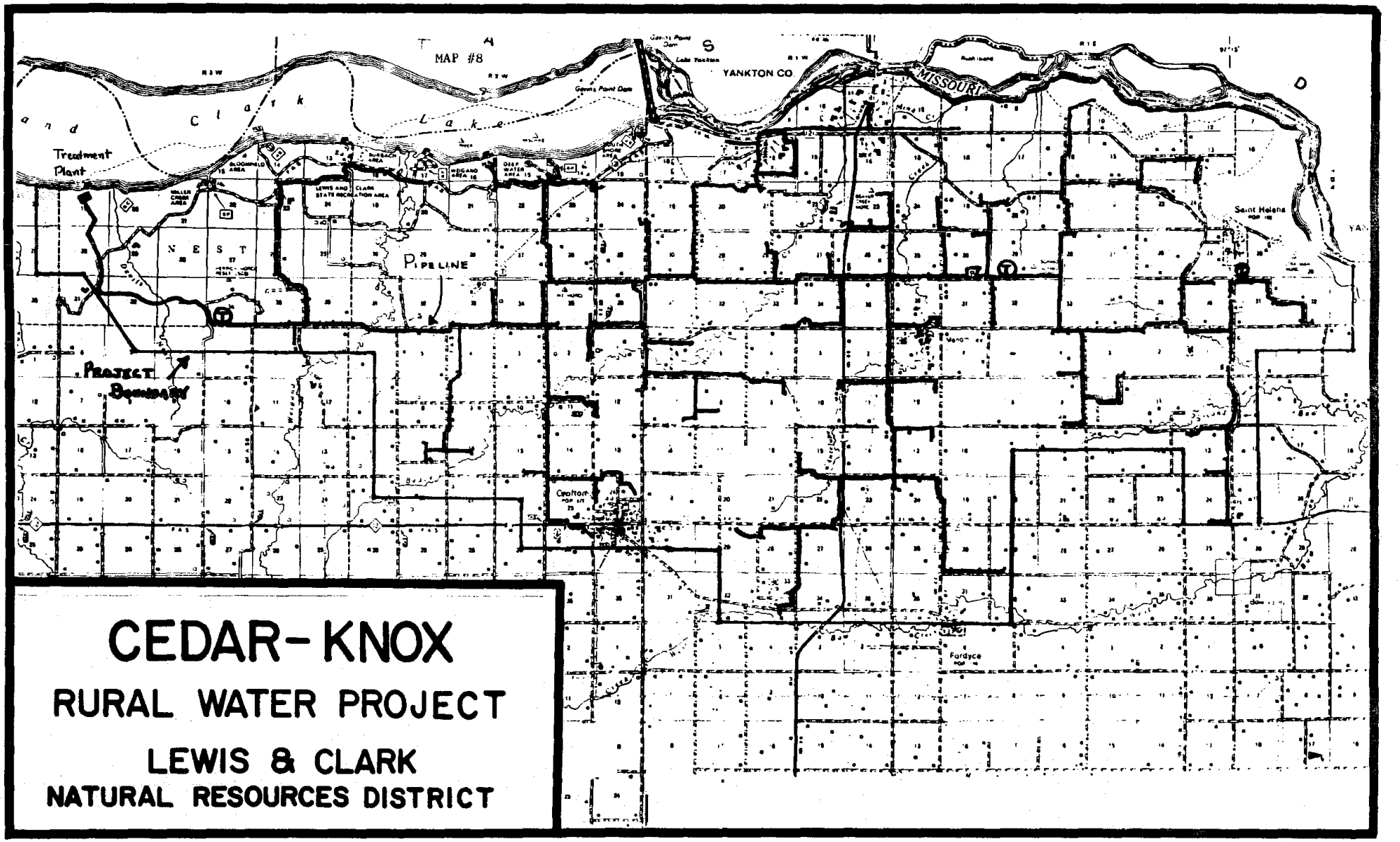
Relating water quality to the aquifers, variable results again prevent specific recommendations (see Table IV-ref. USGS #81-58). Generally, in the Pleistocene or Holocene deposits, if recharge must go through glacial till, the water is likely to be higher in dissolved solids. Conversely, areas recharged by direct precipitation or stream seepage will yield relatively small concentrations of dissolved solids. In the USGS Study of Cedar County for example, wells southeast of Hartington are developed in sand and gravel beds with little or no till above. The water is a calcium bicarbonate type of medium salinity and low in sodium, and consequently is suitable for irrigation on most soils and for moderately salt-tolerant crops (corn, alflafa, oats, and milo). In wells northeast of Hartington, water comes from within the till, is a calcium sulfate bicarbonate type and about twice as mineralized as the previously discussed wells. It is highly saline and low in sodium and will require good drainage soils and crops with salt tolerance (barley). A well northwest of Hartington is similar, but has even more sulfate and therefore probably too saline for continued irrigated use.

Groundwater from the Niobrara formation stays relatively uniform and lower in total dissolved solids. It is a calcium bicarbonate type, medium salinity and low sodium, usually suitable for irrigation of most crops where drainage is adequate. The Dakota Formation has a calcium sulfate type of groundwater usually highly saline and low in sodium. Its salinity sometimes prevents it from being a viable irrigation source and makes it less desirable for domestic and stock supply.

VI. Precipitation Patterns and Variations

The subhumid climate of the area is similar to that of other plains regions, with a growing season lasting from May through September. The hottest month is usually July and the dryest and coldest is January (source: MP-14). Based on the normal monthly precipitation at Hartington, Nebraska in the center of the District, June is the wettest month with 18% of the total annual precipitation (Table V). More than 65% of the total precipitation occurs during the growing season mainly as a result of local thunderstorms. Normal annual precipitation increases slightly from west to east in the District with average records showing about 24 inches per year in central Knox County, increasing to 26 or 27 inches per year in Dixon County. The annual range has been from a low of 14.31 inches in 1976 to a high of 41.45 inches in 1915.

For the purpose of relating precipitation to groundwater, the probability of drought occurence should be considered because of the demand placed on groundwater. An annual rainfall of around 18 inches, for example, is considered much below normal, yet has occurred once in every 10 years. Records taken at Yankton, South Dakota (1931-1960) indicate that the probability of getting a 1.00 inch rain every two weeks ranges from 55% May 1st, to 75% on June 1st, decreasing down to 30% on September 30th


MAP #8
YANKTON CO.
MISSOURI
Clark
Lake
Treatment Plant
PIPELINE
PROJECT BOUNDARY
Saint Helena
Fordyce
CEDAR-KNOX
RURAL WATER PROJECT
LEWIS & CLARK
NATURAL RESOURCES DISTRICT

MAP # 8

(ref. MP-42). However, probability of receiving a trace or less every two weeks during that same growing season period ranges from 5% May 1st, to 0% around June 1st, up to 29% in mid September (MP-10). These variations tell us that groundwater used for agriculture will be in most demand during the months of July, August, and September and that rainfall probability decreases steadily after June 1st.

VII. Surface Water

Because surface water is a possible source of supply to supplement groundwater, it must be considered in the management plan. The major surface water source in the District is the Missouri River. The Department of Water Resources has gaging stations on the river as well as the two main tributary streams in the District, the Bazile Creek in Knox County and Bow Creek in Cedar County (Ref. Water Resources Data, Nebraska).

Because the Gavins Point Dam makes annual adjustments based on flood control and navigation needs, discharge amounts vary. Average river flow taken downstream at the station on the Meridian Bridge was 25,000 cfs for calendar year 1981. Average flow in the same period for Bazile Creek taken at the station on Highway #12 was 36.5 cfs per year. While Bow Creek records indicate 26.4 cfs per year was at the station on Highway #12, which would probably be insignificant for supplementing groundwater supplies.

The Lewis and Clark Lake above Gavins Point Dam is the largest source of surface supply in, or adjoining, the state of Nebraska. In the Crofton Unit Appraisal Report, 1979, the Bureau of Reclamation stated that average annual flow through the Lake was 26,000 cfs over the last 40 years or about 18.9 million acre-feet per year. An irrigation project from the lake would be feasible and economically justified, according to the reference. The lake itself covers 32,000 acres. Quality of the water is good to excellent and the District presently uses this source as a supply for the Cedar-Knox Rural Water Project. Annual project consumption since its start in 1981 has run about 55 to 60 million gallons per year, with expansion treatment capability in place for providing up to 140 million gallons per year. Although ample supply is available, financial limits of potential users may prevent further expansion of service. (see rural water district map #8)

VIII. Supplemental Sources

Supplemental sources of water are amounts added to the existing supply to make up for insufficient quantities. Examples would be surface water, which was covered in the previous Section VII or water brought from a distant or deeper aquifer.

In the Natural Resources Commission's Supplemental Water Supplies Policy Issues Study, mention is made of the off stream storage capabilities that were components of the Crofton Unit Report. Structures for storing 74,300 acre feet in West Bow Creek and 78,500 acre feet on Pearl Creek were considered in one alternative of that plan by the Bureau of Reclamation. The study also mentions the Bazile Creek again, indicating an annual supply available of 48,690 acre feet, but adds that the stream had gone dry near the mouth during drought years, an occurence affecting nearly all streams in the District.

Both the Natural Resources Commission and the Bureau of Reclamation indicated that capacity for increasing irrigation development is present in the District by making use of supplemental water supplies. However, economic factors at present have put constraints on such development, although future considerations may differ. The Missouri River really is the only major source of supplemental supply since the District has only streams and no rivers to utilize. Locally, this fact was recognized in the Cedar County Comprehensive Water and Sewer Plan, 1969, which suggested county wide rural water systems for farm and community domestic use because of the difficulty finding good supplies of groundwater for all purposes.

IX. Existing Groundwater Uses

An inventory of existing use needs to be reviewed to determine what the present demand is on groundwater.

The Natural Resources Commission in Groundwater Reservoir Management, 1982, has some positive things to say on that subject; "the principal aquifer in portions of Nebraska has quantities of groundwater in storage that appear to exceed use-demands over any forseeable period." In this portion of Nebraska, most of the District in 1979 showed that annual recharge from precipitation exceeded the level of irrigation usage. Under realistic projections of development, there is a high potential for utilization without a major impact on the aquifer. Even partial depletion, if anticipated, need not have a significant impact over more than a local area.

Groundwater stored in the principal aquifer is part of an active hydrologic system. Subsurface flow within the aquifer is usually too slow to move into withdrawal areas so that recharge is by precipitation. Under natural conditions the recharge and discharge balance. Withdrawal by pumping results in a combination of decrease in storage, increase in recharge, and decrease in discharge. This means the acutal amount withdrawn will not usually result in a corresponding loss in volume of the amount in storage. In other words, unless use develops to an unforseeable high amount, recharge from precipitation should balance withdrawals and discharge over most of the district over the long term.

By far the greatest use of groundwater in the District is for irrigation. In 1985, there were 479 irrigation wells registered, 26 municipal, and 4 industry in the Lewis and Clark NRD. Land suitability for irrigation is high in most areas, but much of the aquifer is fine grained and provides only low yields of groundwater so that irrigation is not extensive and confined to areas where groundwater is more available and can be found in quantity. Most irrigation in the District is utilized through center pivot systems. In 1984, there were 330 pivots in the Lewis and Clark NRD.

The SCS prepared Multi-Year Plan provides an indication of potential irrigation development. Their figures show over 58,000 acres irrigated in 1985 or 6% of the total cropland acres. That has the potential to increase to 126,000 acres (14%) in 20 years or a maximum of 286,916 acres (31%) that could be irrigated. Other factors such as economics and water availability will affect whether such development takes place.

The available amounts of groundwater as discussed earlier is variable in the District. In "Availability and Use of Water, 1975", Conservation

and Survey #48, mention is made that in subregion #3, which includes the Lewis and Clark NRD as well as the other Missouri Tributaries region, there is about 13,000,000 acre feet in storage which if averaged out for depth, would equal about 6.91 feet of water. In this district, however, (49% of sub #3) the amount of acre feet present in the aquifer is estimated to be about 6,300,000 and the depth in feet ranges from less than 4 feet along the Missouri Bluffs area to 20 to 40 feet in parts of south central Knox County and south western Cedar County. Since some measure of groundwater use is required for this plan, some of the information from this reference will be interpolated to provide an estimate of use.

The same source listed above described 1975 usage at 54,300 acre feet for subregion #3 (Missouri Tributary subregion) which is about 9 times greater than the amount of surface water used for irrigation. There were 215 irrigation wells drilled in Lewis and Clark NRD through 1975, most used on center pivot systems. From percentage calculations for the NRD, we can estimate in 1975 that about 70,000 to 80,000 acre feet (1.2%) left the District through natural discharge to evapotransportation and streams, and an estimated 35,000 (.5%) acre feet was actually used for irrigation, public supplies, livestock, and rural domestic use for a total use or loss of about 110,000 acre feet. Again estimating the figure of 6,300,000 acre feet (approx.) as the total storage, there was only about 1.7% that was used or lost annually. Comparing this use to the recharge rate discussed earlier of 1" per year over the 933,660 acres of the District would give us an average recharge per year of 75,000 acre feet (1.2%), or twice more than the amount used under average conditions, and about equal to the total amount lost to use and natural discharge. Based on this estimation, this would tell us that in 1975 recharge and discharge were about equal and only about .5% of the aquifer was used. It is interesting to note here that we effectively use each year something less than half of what is lost through natural discharge.

Water use has likely increased since 1975, however, a comparison of municipal water use alone in the District from 1979 to 1980 showed an increase from 673 million gallons to 784 million. Even the irrigation wells have more than doubled since 1975. Well monitor records kept by the NRD however, do not indicate that increase has depleted any of the supply.

In determining where water gets used in the District, a breakdown of the 35,000 acre feet per year shows that irrigation uses about 26,800 acre feet (77%), rural domestic and livestock, 6,400 acre feet (18%), and public supplies 1,800 acre feet (5%). This give us an indication of the types of use, the magnitude, and amount (ref: Conservation and Survey #48). The only coordinated use from a different source is the Cedar Knox Rural Water project which supplies treated surface water for rural domestic, livestock, and public use and provides supplemental amounts of 17 acre feet per year.

X. Subirrigation

Subirrigation is the process by which growing plants obtain water from saturated subsoils, resulting from high water tables. In reviewing U.S. Corps of Engineers Wetland Atlas, there are small areas of marsh and riparian wetlands, usually adjoining the Missouri River or its tributary streams, but there are essentially no significant subirrigated areas in the District to merit consideration for this plan.

TABLE VI

AVERAGE EXPECTED CROP WATER USES IN NORTHEAST NEBRASKA

(CROP USE VALUES IN INCHES/WEEK)

WEEK	DATE	ALFALFA	CORN	SOYBEANS
1	4/1 - 7	0.65	-	-
2	4/8 - 14	0.85	-	-
3	4/15 - 22	1.00	-	-
4	4/23 - 28	1.00	-	-
5	4/29 - 5/5	1.05	-	-
6	5/6 - 12	1.10	-	-
7	5/13 - 19	1.30	0.80	-
8	5/20 - 26	1.35	0.90	-
9	5/27 - 6/2	1.40	1.05	0.30
10	6/3 - 9	1.50	1.55	0.35
11	6/10 - 16	1.55	1.55	0.45
12	6/17 - 23	1.60	1.60	0.65
13	6/24 - 30	1.65	1.85	1.00
14	7/1 - 7	1.70	1.90	1.40
15	7/8 - 14	1.75	2.00	1.85
16	7/15 - 21	1.70	1.85	1.75
17	7/22 - 28	1.65	1.70	1.70
18	7/29 - 8/4	1.50	1.40	1.25
19	8/5 - 11	1.45	1.40	1.20
20	8/12 - 18	1.50	1.45	1.25
21	8/19 - 25	1.45	1.40	1.05
22	8/26 - 9/1	1.40	1.10	0.60
23	9/2 - 8	1.20	0.75	0.40
24	9/9 - 15	1.15	0.60	0.20
25	9/16 - 22	1.05	0.35	-
26	9/23 - 29	1.00	0.25	-
27	9/30 - 10/6	0.80	-	-
28	10/7 - 13	0.75	-	-

Note: A killing frost will effectively stop crop water use for the season.

These figures represent averages, their accuracy for a particular week are not guaranteed, these are guide lines (see scheduling method). Crop water use can vary by variety, plant population, and weather. Soil moisture monitoring of some kind is recommended.

Allow for some losses in irrigation efficiency.

Source — University of Nebraska

XI. Crop Water Needs

In attempting to analyze the groundwater needed by crops, many variables enter in the determination. The average length of the frost free period is 162 days (April 29 - October 8). Besides climate discussed earlier, "growing degree days" provide information pertaining to how temperature affects the ability of crops to grow and consequently the water needed.

Growing Degree Days is another way to say that "a certain number of days" over 50 degrees Fahrenheit temperature (40 degrees F for oats) are needed to grow most crops. The number of days plus the number of degrees over 50 degrees each day accounts for that number; which for 90 day corn is 2200 GDD and for 120 day corn is 2800 GDD in Cedar County. The number of GDD for this district between average dates of 32 degree days in spring and fall ranges from 2700 in central Knox County to 3000 in eastern Dixon County. This tells us that the temperature is cooler and growth rates slightly slower from east to west in the District and Nebraska as well. In other words the crop water need is "slightly less as one goes west", and the resulting need for groundwater is greater in eastern areas of the District.

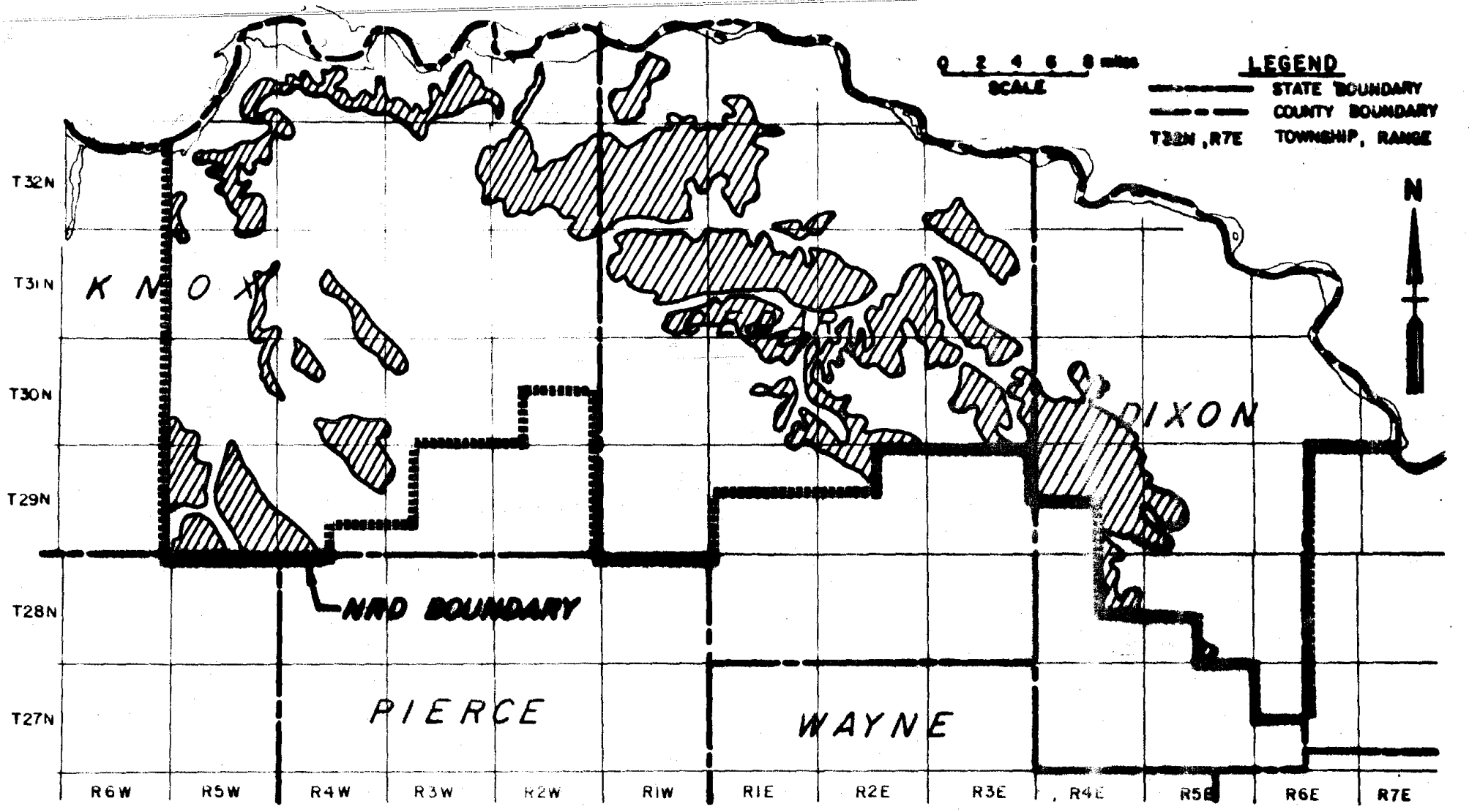
Other methods were used to determine crop water needs. The Nebraska Irrigation Guide, SCS, indicates the net irrigation needed to raise corn and sorghum 10 out of 20 years. In the Lewis and Clark NRD 10 to 11 inches were necessary for a maximum corn crop in that time period while sorghum took about 9 inches. A Water Requirement Study of the North Loup Division also gave some indications on crop irrigation requirements or amounts above precipitation needed for a full crop. Crop water use does vary with the crop and soil type. Sandy soils for instance require more water than heavier soils. The average water extraction depths for different crops are alfalfa, 8 feet; corn, 6 feet; and small grains, 4 feet. Table VI gives an interesting average of cropwater use in inches per week.

Because irrigation use is not extensive in the District, crop water use is not a subject that carries much significance to this plan.

XII. Economic Value of Existing Groundwater Uses

The Groundwater Management Plan Act requires a determination of the economic value for uses of groundwater, but there is little information to base that determination on. As discussed earlier, existing uses include irrigation 77%, rural domestic and livestock, 18%, and municipal, 5%.

Since irrigation comprises a major portion of the groundwater use, it needs to be considered for its economic value. The Crofton Unit Appraisal 1979, researched this in its economic analysis based on local farm budgets and their net income. Comparisons were made on variations with and without irrigation to calculate benefits, and projections made to the year 2020. Since corn is the principal irrigated crop, the report figures showed 1971 variations in yield for Cedar County from dryland at 47 bushels per acre to irrigated at 98 bushels per acre. The year 2020 showed variations in yield for Cedar County from dryland at 70 bushels per acre to irrigated at 175 bushels per acre. Without going into the details here on prices paid and received as well as production costs, the report indicated an irrigation benefit of $164 per acre on irrigated compared to



Soil Associations having excessive drainage and more likely to show contamination from surface leaching.

Soil Associations less likely to show contamination from surface leaching.

MAP # 9 SOIL ASSOCIATIONS

dryland.

For irrigation use, other comparisons can be inferred from the Estimated Crop and Livestock Production Costs EC 84-872. The availability of groundwater that could be utilized for irrigating corn made possible expected yields in Northeast Nebraska of 130 bushels per acre, compared to similar tests on dry land with expected yields of 75 bushels per acre. A similar comparison for irrigated soybeans at 45 bushels per acre with dryland at 30 bushels per acre. These results indicate that irrigation has a significant impact on yields in Northeast Nebraska. Of course, production costs need to be considered on this but generally speaking the use of irrigation results in a higher economic value for groundwater than dryland agriculture. The price of land is also enhanced by the availability of irrigation.

Assigning values to rural domestic, livestock, and municipal uses of water is more difficult. Comparisons from the District's Rural Water Project shows what treated surface water is worth to users of the project who desire rural water pipeline services where available, to avoid the use of groundwater in the areas where quality sources are a problem. 1985 rate shcedules have minimums of $20.00 for the first 1000 gallons charged monthly and bulk rates are $1.25 per 1000 gallons. The average user of 11,500 gallons per month pays $44.00 ($530/year). This would indicate the economic value of quality water over non-quality water if comparisons could be made with private well installation and maintenance costs.

Published information is of little use in calculating economic values for most uses of groundwater in the District because there are so many circumstances affecting each user. It is very difficult to place a dollar value on water when a municipality, for example, finds a quality problem in its source. Different alternatives must be examined for each situation to determine a course of action. Generally stated aquifer limits on water availability restrict any exonomic value for development of groundwater in the NRD.

XIII. Coordinated Uses from Different Supply Sources

The Cedar Knox Rural Water Project is one example of the use of treated surface water to supplement poor quality groundwater. Users on the system in many cases combine the supplies to improve their overall quality to the economic degree they can best afford. The town of Crofton uses treated surface water as it can afford in conjunctive use with its minicipal wells. Farmers use treated water for household use and well water for livestock in many cases. The project although insignificant in quantity impact on the groundwater use of the District, nevertheless illustrates the fact that where there is a need and a financial interest, coordinated uses can be developed to the benefit of the District when dedicated efforts are put forth.

The Crofton Unit Appraisal Report in 1979 represented an effort to consider irrigation possibilities from Lewis and Clark Lake into Knox and Cedar Counties. The report resulted from successive dry years that sparked a demand for a study by the Bureau of Reclamation; but by the time the positive results were presented, proponent interest had dwindled and opposition rose, giving little support for the project. It is generally recognized in the District that conjunctive use of surface water for irrigation will not be a viable need until economic factors show commodity prices will off set the expenses.

No other integrated uses of surface water with groundwater has been contemplated to the knowledge of the District. The importance here is to note that quality groundwater is a prime commodity, and that in its absence where interest is sincere and local involvement active, coordinated use can be very effective and beneficial.

XIV. Conservation of Groundwater

Because of the topography of the area, the NRD is convinced that conservation practices play a major role in reducing groundwater application needs and reduction of surface erosion problems resulting from groundwater runoff. It continues to provide a number of programs available to help landowners make more practical use of groundwater by means of reduced run off, management alternatives, increased precipitation recharge, and erosion control measures. With the technical assistance of SCS, the NRD offers the Habitat Program, Cost Share payments on terraces and dams through Nebraska Soil and Water Conservation Program and local funds, tree planting and grass drill services, conservation tillage test plots, and watershed erosion and flood control dams. Although estimates of the magnitude of groundwater saved would not be possible, the amount could significantly affect the resources.

When discussing conservation of groundwater, the main concern is to use best managment practices on the land so as to minimize the amount of groundwater required for irrigation or make the best use of water on the soil surface to reduce quality problems from leaching. Best management practices are solutions used to accomplish these means. They include: conservation tillage which utilizes different tillage means to keep at least 20 to 30% crop residue on the soil surface after planting to conserve moisture and reduce soil erosion from rainfall; contour farming decreases runoff by creating furrows around rather than up and down hills crop rotation and strip cropping with small grain or cover crops create diversity in the ground cover and act as vegetative filters to remove sediment and slow runoff; terraces reduce erosion by breaking up the long slopes into several short sections to reduce the speed and amount of runoff, while grass waterways provide for controlled release of that water along natural drainage ways; ponds and dams actually stop and release the flow of water and can act as a major source of groundwater recharge for an immediate area. These practices used alone or in some combination are considered the most practical and effective methods to maintain water quality and conserve our groundwater resource (ref. Neb. Guide #G82-586). Along with them, such practices as irrigation scheduling, soil testing, and proper storage and handling of fertilizer contribute to improved conditions to preserve groundwater quality.

SUMMARY: A REVIEW OF ASSETS

The Lewis and Clark NRD has a complex groundwater reservoir that forces the technical focus of this plan to be very general. Any specific descriptions would require new studies and investigations. Generally speaking the NRD has a variable groundwater resource, limited by geologic factors as well as some quality factors, but with an estimated storage of 6,300,000 acre feet which should still provide a dependable source in most areas. Because the aquifer is absent or very thin and transimissivity is

limited, groundwater stored is not easily located or withdrawn, resulting in wells with low yields.

To begin with the reservoir itself, the principal aquifer is the Pleistocene and Holocene deposits which are found across the District. Of secondary concern because of limited availability is the Niobrara formation; and because of depth and water quality the Dakota formation. Information on depth of the primary aquifer shows that it ranges from 0-200 feet. Transmissivity or flow rate limits irrigation development (groundwater movement tends to move east-northeast toward the Missouri River). Depth to groundwater itself is usually in the range of 50 to 200 feet with exceptions both ways. Static levels have remained constant indicating no immediate threat to groundwater quantities. Recharge comes through precipitation and based on average estimates, amounts to an inch or less per year, even though soil structures could usually handle more.

Groundwater quality is the Districts most serious concern. Most of it is good to excellent, but not always low in total dissolved solids. Calcium and magnesium along with iron and manganese are found often and associated with hardness but are considered more a nuisance than a health hazard. Likewise, sodium can cause some irrigation management problems and diet concerns. Of a more serious nature is nitrate-nitrogen which usually results from leaching into water tables affecting primarily domestic wells. Prevention is emphasized to avoid expensive relocation or treatment of existing contaminated supplies. Drilling deeper wells to avoid nitrate contamination is not always a practical solution. As is apparently the case in the Creighton area, isolated cases of groundwater pollution are increasing. Generally, areas in the northern part of the District appear to be more susceptable to point-source problems and the southern part to non-point source problems because of the aquifer characteristics.

A review of other water resources in the area show that rainfall probabilities during the growing season of crops decreases steadily after June 1st. Surface water supplies exist in insignificant amounts from Bazile Creek and Bow Creek but in major amounts from the Missouri River and Lewis and Clark Lake. the Cedar Knox Rural Water Project makes use of this source for a domestic supply system using 17 acre feet per year. The Crofton Unit Appraisal Report (Bur. of Reclamation, 1979) considered irrigation a feasible and economic possibility that could also be used for artificial recharge or a supplemental source. Utilization of the Lewis and Clark Lake will not be a viable need until economic factors and local interests support it.

Groundwater use as determined by Conservation and Survey Paper #48, 1975, shows that on an annual average we use .5% (35,000 acre feet) and lose to natural discharge about 1.2% (70-80,000 acre feet) of our total groundwater in storage. During the same time it gets recharged about 1.2% (75,000) acre feet. Groundwater monitor records however, indicated no apparent reduction in water tables since 1975, so that the average loss figure qualifies as insignificant because recharge and discharge usually balance each other out in this area. Most of the groundwater used goes to irrigation use (77%) with rural and livestock next (18%) and municipal last (5%). Subirrigation is not a factor and little information is available on crop water needs. Economic values of existing users are highly variable and not available in terms of making substantial statements here. Conservation of groundwater has been and remains a

serious effort of the NRD which makes available various programs to encourage practical use and management alternatives.

Collectively speaking then, the Lewis and Clark NRD has geologically limited groundwater quantities available. Irrigation growth where practical has presently peaked and well measurements indicate water levels are not dropping. While rainfall still limits crop production from year to year, economic justification for bringing in supplemental supplies does not appear to merit doing so. The information available indicates that groundwater quantity is generally stable, that future development of the supply will require a significant economic need, and that maintenance of groundwater quantities can be accomplished by continued static-level monitoring of the resource.

Groundwater quality does appear to be a growing problem however. Most groundwater sources are naturally high in total dissolved solids and hardness. Because it would be difficult to enforce more strict standards, the District needs to follow Federal or State acceptable limits on chemicals of concern. At present the most serious inorganic chemical threatening groundwater users in the District is Nitrate-Nitrogen. More information is necessary to determine the frequency and scope of its presence, while still keeping in mind the financial and staffing limitations of the District.

POLICY CONSIDERATIONS ON GROUNDWATER

RESERVOIR LIFE GOALS

NRD policy needs to be reviewed and considered to decide on a future course of action for the management of groundwater in the District. Those decisions shall be based on the technical information available and need to identify specific groundwater management policies. Among those policy requirements are developing objectives, including a groundwater reservoir life goal, and setting management area boundaries. In addition, proposed controls or program options along with their impacts need to be considered.

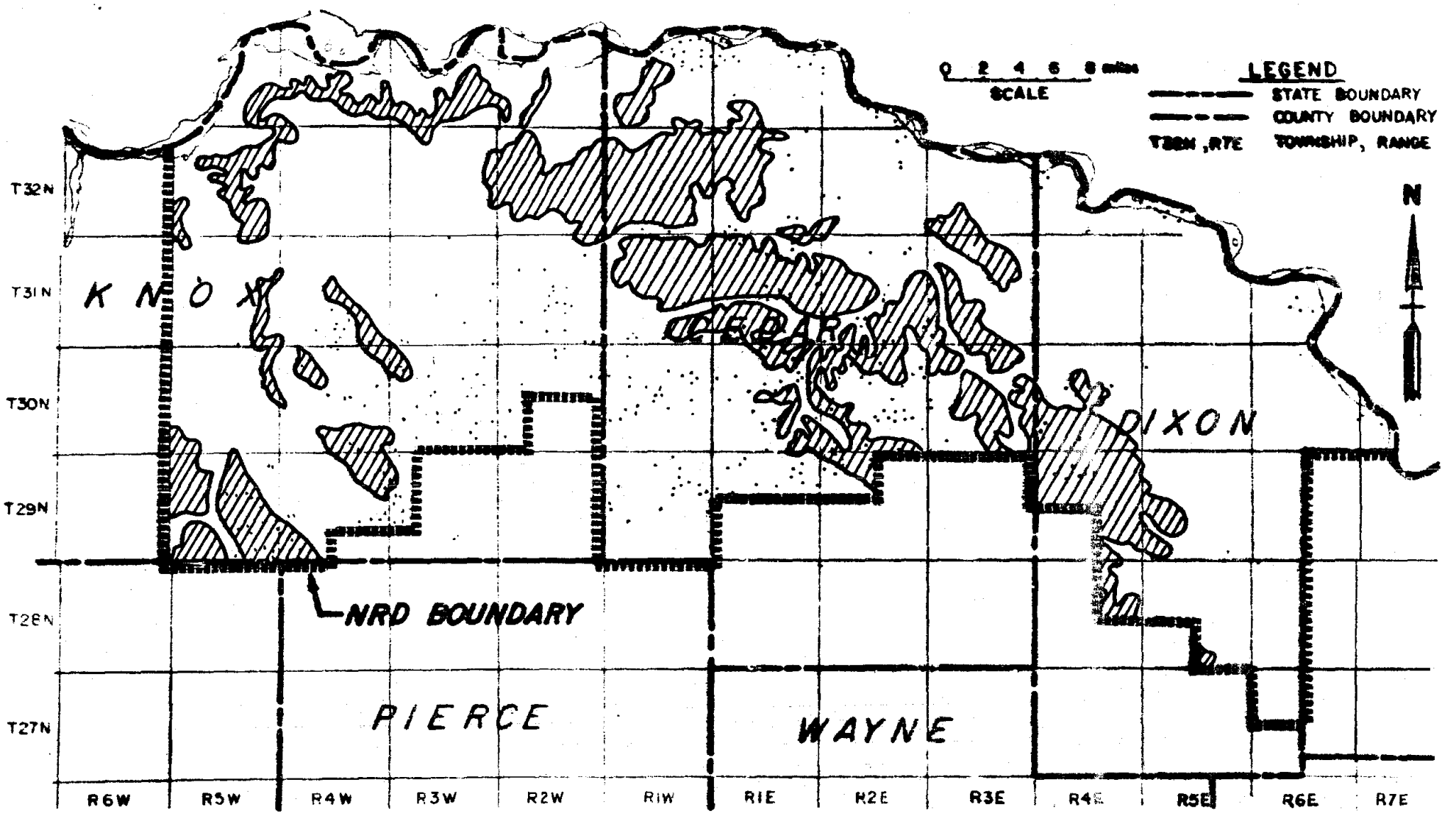
Since the statutes require a groundwater reservoir life goal for maintenance of the supply of water, the NRD must set a period of time that it hopes to be able to obtain water from the reservoir. Because specific data for the District is unavailable to set a specific time, that goal must be generalized as follows: To preserve and maintain the natural quality and quantity of groundwater an indefinite period of time for the sustained use of the resource. In other words the NRD would expect to be able to obtain water from the reservoir consecutively for indefinite years. Technical information from this report reflects this status and no dramatic changes are foreseen.

A review of that information indicates that the District does not have an immediate problem in the future on water quantity although maintenance by static level well monitoring shall continue. The quality however, does merit attention and cause for increased planning efforts. The areas of concern from a possible management area basis for consideration, is where soil associations with excessive drainage coincide with concentrated irrigation use and the aquifer is being more utilized. Potential management areas as shown on Map 10 can be roughly described as areas which have the most potential for water quality problems in the present and future because of possible leaching of groundwater contaminents. Outside of the area quality problems are generally thought to be less likely and limited to isolated locations or individual source contaminations.

Having set a goal for the reservoir, management objectives need to be developed to sustain that goal. Objectives are specific statements about the methods to maintain or improve the reservoir situation. They can take the form of data collection processes, program options, or controls. Examples of the types of objectives considered to meet the goal are: monitoring of quality and quantity, water conservation programs, conjunctive use management, and groundwater management and control areas. Along with the objectives, the impacts and affected results on the goal need to be considered. Social, economic, physical, financial, institutional, or environmental factors all play a role in determining the best method in achieving the goal.

REVIEW OF POTENTIAL OBJECTIVES

Several references were consulted for recommendations on management objectives. Recognizing future problems in water quality for this NRD that may develop, aspects need to be considered to evaluate which objectives would be most effective in meeting the need. Following are several of those possible solutions:



Soil Associations having excessive drainage and more likely to show contamination from surface leaching.

Soil Associations less likely to show contamination from surface leaching.

MAP #10: ILLUSTRATION OF POTENTIAL MANAGEMENT AREAS FOR WATER QUALITY

MAP # 5 Registered Irrigation Wells thru 12/31/84 in the Lewis & Clark NRD
Overlying MAP # 9 SOIL ASSOCIATIONS

I. The Hall County Water Quality Report, 1984, reviews a response to a groundwater quality problem of the accumulation of nitrate-nitrogen. To confront that problem the Hall County project set the following objectives:

1. Impede the leaching of nitrates from fertilizer into the aquifer.

2. Remove existing nitrates through irrigation.

3. Demonstrate efficient management of nitrogen with irrigation.

4. Develop practices for application elsewhere in Nebraska.

The effort to implement these objectives was accomplished through cost-share incentives, individual consultation, group educational meetings, newsletters, field demonstrations, and yield checks. The lead agency in this case was Agricultural Stabilization and Conservation Service. Two full time specialists and seasonal employees were hired over apparently a four year period to work on the project which showed positive results. It demonstrated that irrigation scheduling and water measurement are useful tools for improving irrigation management without loss of yields, and limiting leaching of nitrates into the groundwater. The Central Platte NRD is carrying out education on these procedures in its District by using demonstration areas.

II. Nebraska EC 81-2400 "Living with Nitrates" explains in common terms, the nitrogen cycle, leaching hazards, and the affects on ffod, livestock, and domestic supplies. It indicates nitrate contamination most often occurs from leaching and that on irrigated soils the control of excess fertilizer or excess water will reduce the amount of nitrate contamination. Once present in a water system, nitrate can be partially removed by three methods; Distillation (boiling of water and collecting the steam), Reverse Osmosis (pressurized filter process to remove impurities), and Deionization (electronically charged removal). All of these methods are expensive in one form or another and involve a certain degree of technical capability. The need should be definitely established by checking with professional consultants. Other alternatives to nitrate removal are relocation or deepening of wells, or using pure bottled water.

III. A review of the Policy Issue Study on Groundwater Reservoir Management, 1982, indicates that the NRDs principal aquifer can provide moderately large supplies of water but usually of limited areal extent. Small areas of decline can be expected, however, many are seasonal and could respond quickly to variations in amount of withdrawal. This indicates best management objective by analysis of local conditions.

The Policy Issue Study provides an excellent review of potential techniques for groundwater management. It explains that a variety of objectives could be utilized to achieve our goal, but to be effective the techniques must function within the capabilities of the resource and consider the stress or impact resulting from development.

If potential restriction of groundwater development is thought a necessary objective to maintain or extend aquifer life, the following management actions could be taken:

1. Reduce irrigation water need by improving efficiency.

2. Reduce irrigation water need by improving crop water use efficiency.

3. Reduce irrigation water need through improved conservation practices.

4. Reduce groundwater development based on water supply criteria.

5. Reduce groundwater development based on geographic and environmental criteria.

6. Reduce groundwater withdrawals to prolong supplies and reduce environmental impacts.

All of the above actions can be elaborated on by methods to encourage or require irrigators to adopt practices that will help the situation or to not develop wells that will cause problems. Research, demonstration, financial incentives or disincentives, and legislation or administrative action are tools that could be used to accomplish these management actions.

IV. Another Policy Issue Study on Municipal Water Needs, 1983, suggests several alternatives for problems relating to municipal water systems. Most of the recommendations involved legislative statutory changes or state wide alternatives. Although some might be encouraged by the NRD, they are not being considered as local objectives.

V. A research paper entitled "Nitrate Pollution of Groundwater in Nebraska and Policy Options to Address It" by Linda Willman, 1984, was reviewed for possible recommendations for water quality maintenance. Among the major points made in the study were the following:

1. Irrigation and fertilizer management are interdependent and should be mutually cooperative efforts...including an accounting for all sources of nitrogen available to the crop.

2. Factors affecting nitrate leaching include; depth to water table, soil permeability, seasonal rainfall, organic matter, microbial activity, fertilizer and irrigation practices, and crop uptake of nutrients.

3. The potential for nitrate leaching below the plant root zone is especially high in spring and fall precipitation periods...(more so too on sandy soils)

4. Soil testing and utilizing residual soil nitrogen is a key factor in effective nitrogen management.

5. Point source pollution has generally been related to septic tanks, feedlot runoff, and fertilizer spillage.

6. Proper well location and construction are critical in reducing the risk of nitrate contamination.

7. As groundwater nitrate contamination is documented with regard to point or non-point sources, feasible efforts to control leaching will need to be employed.

8. As the use of nitrogen fertilizer has increased, the practice of

rotating crops with legumes has decreased, which generally contributes to nitrogen contamination of our drinking water.

9. NRD's across the state must consider regional supply systems or cooperatives as alternatives for communities with contaminated supplies.

10. Best management practices should be used with fertilizer and irrigation application methods.

VI. Other NRD's in the state are working on programs that provide more information on water quality to document where and what their problems are. The Middle Missouri NRD (Walthill) is working on an extensive quality measurement program primarily through the efforts of their County Extension Service personnel. The Lower Loup NRD (Ord) publishes an annual report on water quality samples taken, one per township, across the bulk of their District. Their tests include the date, conductivity, pH, nitrate-nitrogen, alkalinity, chloride, sulfate, and iron. The tests are apparently taken annually at domestic wells with the results analyzed and provided by the NRD with their own lab equipment.

Other Districts as well do similar testing and special studies to evaluate groundwater quality information. Concern over liability on testing results however, makes professional testing more advantageous to utilize.

VII. In Overview of Nitrates in Groundwater, NRC, 1983, Remedial Action for Nitrate Problems are discussed. Three options considered in the publication are: using different sources, removing nitrates from the water supply, and reducing the amount of nitrates entering the groundwater. The report says that most contamination problems in the eastern part of Nebraska are localized problems as opposed to a widespread area contamination. In those local areas contamination usually results from activity around the wells in the form of poor well construction or point sources of pollution.

Standards for measurement of nitrate amounts is important and minimum procedures are suggested. "Hach Kits" used presently by some NRD's including Lewis and Clark NRD should not be considered for a high degree of accuracy and reliability. Remedies in this publication discuss different means of working with the problem, all of which have been discussed previously in this plan.

VIII. The Nebraska Groundwater Quality Protection Strategy addresses the aspect that the state has not been aggressive in protecting its water quality. As a result, considerable legislation may be required in the future to protect groundwater supplies from pollution; from chemical and fuel storage, agriculture chemicals, waste treatment and disposal areas, improper design, installed or abandoned wells, industrial facilities, and accidental spills or leaks.

They suggest local Special Project Areas could be designated to regulate sources of potential contamination and that NRD's could work with them to develop and implement protection measures.

Their strategy for dealing with future Nitrate contamination issues includes further reviewing the harmful effects, developing legislation, regulating fertilizer applicators, registering chemigators, establishing best management practices and developing monitoring programs.

IMPLEMENTATION OF OBJECTIVES

While several alternatives can be considered for a course of action, the NRD must consider which objectives apply to the local area and what impacts they might have. Since most of the present groundwater problems are centered on quality concerns, it is important to establish and support, with adequate base data, what and where existing quality concerns are before decisions are made on the proper objectives. The Department of Health can not provide specific locations of their past testing experiences so the District shall consider a monitoring system of its own. Once data is available, education and demonstration programs to encourage conservation and best management practices should logically follow. The chart on Table VII gives a progressive indication of the alternatives considered workable by the District and what their respective impacts might be. It also outlines the implementation schedule for how those alternatives shall be utilized and their order of consideration.

The Lewis and Clark NRD has limited capability for implementing major program changes specifically for groundwater alone. With a valuation among the smallest in the state and utilizing close to its full levy, the District cannot expand readily to absorb added program components and costs. As situations arise a determination needs to be made by the Board of Directors on the balance necessary to create a program to meet serious groundwater needs as compared with the costs in tax dollars to protect the resource. In other words, criteria needs to be set to help directors decide on how severe a groundwater problem needs to be present before more expensive objectives are utilized to deal with it. The following policy shall be utilized for that purpose, according to the objectives considered:

1. Conflict Resolutions - On-going program, District will attempt to resolve issues between parties without advocating one cause over the other. Groundwater is public property, its use should be shared for the mutual benefits of all concerned. If applicable, rules and regulations of the Nebraska Groundwater Management Act on improper irrigation runoff or illegal wells will be used.

2. Legislative Support - On-going program, District will support legislation that provides local control with the groundwater management tools necessary to preserve and maintain the resource and oppose those which it feels harms that authority.

3. Expand Monitor Program - Already active in quantity monitoring program, the District will seek to expand that effort to obtain base data on quality problems. Domestic well information would support issues of public concern and irrigation well monitoring would more accurately indicate area-wide aquifer problems. Location shall be selected based on potential quality problems and prompt respectable testing will be necessary to make accurate determinations.

4. Education and Demonstration - On-going program, District will continue conservation practice emphasis and as specific quality problems are determined, broaden that effort to educate the public on contamination concerns, fertilizer management, nitrate utilization, or other issues.

5. Supplemental Supplies - On-going Program, District administers the Cedar Knox Rural Water System and can expand off that base to serve others in the District. Criteria necessary to consider a supply system should be: lack of alternate quality sources to numerous users, consideration of treatment expenses for using present sources, economic potential for financing a project and availability of interested and dedicated local participants.

6. Groundwater Management Area - If objectives mentioned previously prove ineffective or seem unworkable the District will propose a management area to address irrigation or non-point pollution problems. Since present laws provide limited capabilities in quality situations, criteria for this objective will require that problems be shown to affect the aquifer for more than just a few isolated users, and there exists a serious pollution problem that can be corrected with irrigation regulation or fertilizer management.

7. Groundwater Control Area - If a management area does not appear to address groundwater use problems related to irrigation, then a control area might. Serious non-point pollution occurrences or irrigation development expanding beyond isolated cases that cause economic hardship and affect the aquifer in general, are necessary before initiating a control area. Approval must be made by the Department of Water Resources.

In summary, the Lewis and Clark NRD believes that the technical information presently available indicates that the District in general does not have serious groundwater quantity problems. Quality, however, particularly nitrate-nitrogen is a growing concern and merits increased monitoring efforts. Hard water is common to the area, but contamination events appear to be increasing.

The policy of the NRD will be to continue on-going programs to achieve our goal to preserve and maintain the natural quality and quantity of our groundwater resource. In addition, the District intends to expand its monitor efforts in groundwater quality and to establish an adequate data base to provide a basis for future decision on the need for management or control area objectives to achieve our goal. Lastly, the District will actively strive to address those groundwater problems that arise in the future by using the tools available to locally administer the programs necessary to protect our valuable resources.

TABLE VII -- IMPLEMENTATION SCHEDULE

PROGRAM OBJECTIVES	METHODS	IMPACTS
1. Groundwater Conflict Resolution	1. Negotiate without taking sides to seek a mutually acceptable solution. Emphasize groundwater is public property. Utilize 1975 Groundwater Management Act.	1. Staff time, expert assistance necessary but less likely to involve lawsuits under present laws.
2. Support Legislative Action	2. Case by case analysis and contribution to support local control authority	2. Variable, wide range of impacts possible
3. Insitute Monitor Program on Water Quality	3. Work with Extension & Conservation & Survey on procedures & testing to obtain results from domestic and irrigation wells	3. Technical requirement, time involved in set-up coordinating samples--low impact economically, socially, or legally. Teting lab respectability is a concern.
4. Education & Demonstration Programs	4. Coordinate with Extension, Dept. of Health, & Dept of Environmental Control on public information meetings	4. Minimum costs and time involved on small scale programs. Additional staff necessary if area wide project started (ref. Hall Co. report)
	A. Demonstration on Conservation Practices	A. On-going programs
5. Conjunctive Use & Supply Augmentation	5. Utilize water from Missouri River for Domestic supply alternative	5. On-going program. limited for economic reasons to northern Cedar-Knox Counties.
	A. utilize other sources for development of rural water systems	A. Requires considerable time of staff and dedicated volunteers, suitable sources, financing & sincere need.
6. Establish Groundwater Management Area	6. NRD holds public hearing, defines area, works with DEC, adopts controls and sets limits on use by allocation, rotation, well spacing or irrigation scheduling & fertilizer management.	6. High administrative requirement, economically expensive, social acceptance variable
Management Options	A. Reduce irrigation need by improving effeciency	A. Incentive needed--new legislation helpful
	B. Reduce irrigation need by improved crop water use	B. Educational requirements, violation needs
	C. Reduce irrigation need by improved conservation	C. Cost-sharing funding needs to be available
	D. Reduce development based on water supply	D. Set limits on amounts used for irrigation
	E. Reduce development based on environmental criteria	E. Set limits on amounts used for irrigaiton
	F. Reduce development to prolong supplies	F. Reduce withdrawals by education &Rregulation
7. Establish Groundwater Control Area	7. NRD holds public hearing, defines area, works with Dept of Water Resources, adopts controls & regulations reports, investigations, rotation, well spacing, meters, allocation, or cease and desist orders on new well drilling	7. High administrative requirement, economically expensive, socially difficult. Well permits required regulated use of irrigation can restrict development.

PUBLIC INVOLVEMENT ACTIVITY

As part of the planning process, Natural Resource Districts are required to actively solicit public comment and opinion during the preparation of a groundwater management plan.

The Lewis and Clark NRD did this by regular newspaper articles across the district before and during the planning process to invite comment at regular monthly meetings where the issue was on the agenda from February through November, 1985. An advisory task force of locally concerned citizens was appointed, and met twice during the year to provide direction. A publicly advertized meeting concerning the groundwater management plan was held on August 1, 1985 following newspaper publication and radio announcements discussing agenda items.

The task force committee was appointed by the NRD Board of Directors and consisted of: Lyle Vawser-Cedar County Extension Agent, Jerry Langhorst - Creighton Mayor, Terry Gompert - Knox County Extension Agent, Brad Jones - Small Farm Resources Project: Water Policy Specialist, Bruce Hanson - Conservation and Survey Division, Bill Christiensen - well driller, Jim Wortmann - farmer, NRD Director, Dan Pierce - SCS, District Conservationist, Lou E. Benscoter - farmer, NRD Director, Bill Pick - irrigator, farmer, and Jess Wolfe - science teacher. They met initially on March 12, 1985 to review technical data and direction, and again on September 20, 1985 to review comments received and provide recommendations on goals, objectives, and policies. Their input was approved entirely by the NRD planning committee on September 19, 1985 and incorporated into the plan.

Comments received from the task force as well as the public meeting August 1st (which had a total attendance of thirteen) were for the most part worked into the plan. Following review by Department of Water Resources and the Conservation and Survey Division, their comments were added as well. The final Groundwater Management Plan was reviewed and adopted at the November 21, 1985 meeting of the Lewis and Clark NRD Board of Directors.

Update of the plan will be considered as the need requires it or when the District reviews its official Master Plan.

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LEWIS & CLARK
Natural Resources District

N. Highway 15
PO Box 518
Hartington, NE 68739
Phone (402) 254-6758

February 9, 1995

RECEIVED

FEB 10 1995

DEPARTMENT OF
WATER RESOURCES

J. Michael Jess, Director
Dept of Water Resources
PO Box 94676
Lincoln, NE 68509-4676

Dear Mr. Jess:

The Lewis & Clark NRD is again re-submitting our Groundwater Management Plan amendments as requested in your letter of September 16, 1994.

I am providing you with seven copies of replacement pages for you to remove and substitute in the plan sent previously. In most cases only minor changes were made subsequent to visits with Dale Vagts and Sue France. To address the concerns mentioned in your letter, let me summarize those change briefly:

Abstract page: Revised to clarify water quality trigger only
Page 53: Table IX results 92-94 absent because data not available - sample wells were not run.
Page 65: Reservoir life goal defined as "infinitely" (Table X reference added)
Page 66: Selected clauses removed to clarify commitment to significant actions - "large area" and "boundary delineation" defined -- Extent of irrigation and action tools clarified at request of D.E.Q.
Page 67: Water Quantity trigger reference deleted because of confusion caused by baseline levels. NRD will revise as part of Master Plan update in future.
Page 69: Table X added to illustrate Groundwater Quality objectives at suggestion of UNL Conservation and Survey Division.

Feel free to call if there are remaining questions on any of these changes. The Lewis & Clark NRD after visiting directly with the people noting concerns feels confident the changes should be acceptable and that the revised plan might soon be approved.

Sincerely,

Tom Moser

Tom Moser
General Manager

ms

cc Dick Grosvenor, NRD Chairman

Recycled Paper

LEWIS & CLARK
Natural Resources District

N. Highway 15
PO Box 518
Hartington, NE 68739
Phone (402) 254-6758

June 30, 1994

RECEIVED

JUL 1 1994

DEPARTMENT OF
WATER RESOURCES

J. Michael Jess, Director
Department of Water Resources
PO Box 94676
Lincoln, NE 68509-4676

Dear Mr. Jess

The Lewis & Clark NRD is re-submitting our Groundwater Management plan Amendments as requested in your letter of October 4, 1993. The Plan incorporates suggestions made by the various agencies, including extensive discussion with the Natural Resources Commission and was approved by the Board following a public hearing on June 16, 1994.

I am providing you with seven copies of replacement pages for you to remove and substitute in the plan sent to you previously. Please remove and replace pages 62 through 68 and add Appendix G. A revised Abstract page with Table of Contents is also enclosed.

To address the concerns of your October letter we have modified the following parts of our plan as follows.

1. Identify Sources of Groundwater Contamination

Appendix G is provided to give a more detailed listing of known point sources. Because of the transient nature of the information we had previously made reference to it only but included it with the plan now to accommodate your request.

2. Identify Long Term Solutions

We have revised our goal and triggers for groundwater quality and quantity as noted on pages 65 to 68.

This plan also incorporates the revised endangered species wording previously agreed upon with Game & Parks concerning the Western Prairie Fringed Orchid and other species. It also corrects reference to statutory changes from LB131 in Section VIII as noted.

The Lewis & Clark NRD hopes these changes are acceptable and that the revised plan might soon be approved.

Sincerely,

James Wortmann,
NRD Chairman

ms

Recycled Paper

ABSTRACT

The Lewis & Clark NRD is adding an amendment to its original plan to comply with state legislation. Goals and objectives of the plan remain similar, but some objectives have been modified.

Additional information has been incorporated into the amendment under a format outline proposed by Dept of Environmental Quality and Department of Water Resources. NRD directors have provided input in the draft process and the amendment was reviewed at public meetings and hearings. Specific data relating to the Lewis & Clark NRD is still strictly limited although it is likely that some water quality problems are point-source related. It is presently premature to consider a Groundwater Management or Special Protection Area because of the lack of supporting information, the relative small size of areas having concern on water quality, and the positive response to voluntary education and incentive programs in such areas.

Modified objectives include continued and intensified monitoring efforts to determine the "scope and trend" of contaminant levels in critical areas of the District. Voluntary Preventive Programs are offered District wide or targeted to concentrate their effectiveness. They include:

1. Deep Soil Testing Program
2. Sealed Well Abandonment Program
3. Wellhead Assistance Program
4. Information and Education Program
5. Rural Water Distribution Projects
6. Chemigation Permit and Inspection Program
7. Other Projects that become legally available

The Lewis and Clark NRD will resort to regulatory authorities under state law by means of Management or Special Protection Areas as "scope and trend" of contamination dictate. That significant point for water quality will be when 50% of the samples taken over a large area shows an increasing trend for 3 years that reaches 90% of Maximum Contaminant Level.

The NRD believes voluntary programs have been popular and effective as well as preventative. Existing data in some areas attributes contamination to previous poor well construction and consequently point-source origins. For these reasons regulatory programs at this time do not appear necessary or practical.

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E. GROUNDWATER MANAGEMENT PLAN AMENDMENTS -- 1993

I. INTRODUCTION:

Action by the 1991 Nebraska legislature enacted with LB 51, required Natural Resource Districts across the state to amend their individual Groundwater Management Plans by July 1, 1993. The purpose of this effort will be to define more specifically, groundwater contamination potential and solutions to consider for management of the groundwater resources. This amendment section will not address quantity issues unless they might relate to quality concerns. The district believes it has made significant progress concerning original objectives, especially in areas of data collection and program options regarding quality aspects of the original plan. This amendment will follow the reference outline of July, 1992 provide by DEQ and DWR.

The Lewis & Clark NRD will utilize current information that is available to supplement the existing 1986 plan. In some cases technical data will be presented here that will update that plan or provide additions to it. A review of comments made on the original plan indicated that technical portions of the plan were well written, based on information available, so that this amendment section will not repeat that data. Individual sections will be reviewed and revised according to current information available, as appropriate. It should be acknowledged here, that present data is not adequate to make specific planning decisions for some plan components.

II. Hydrogeologic Characterization

This information was presented in the original groundwater management plan, as it relates to aquifer description, groundwater recharge, and other related soils and hydrogeologic data. Additional vulnerability information is available from the DRASTIC map (shown on Map #11). This describes areas that may be susceptible to contamination in generalized situations. Out of a class rating of 1 to 8 on degree of vulnerability, 86% of the district falls under a rating of 4 or less indicating low risk in those areas. More current information on the Bedrock Geology is available now through the Sioux City Quadrangle map I-1879 (1988) produced by US Geological Survey which better illustrates information previously covered in the initial Groundwater Plan. The entire NRD is located in the glacial till area of Eastern Nebraska which separates it from other parts of the state in regards to groundwater quality impact. Those distinctions make hydrogeologic generalizations quite difficult and consequently severely limit plan components.

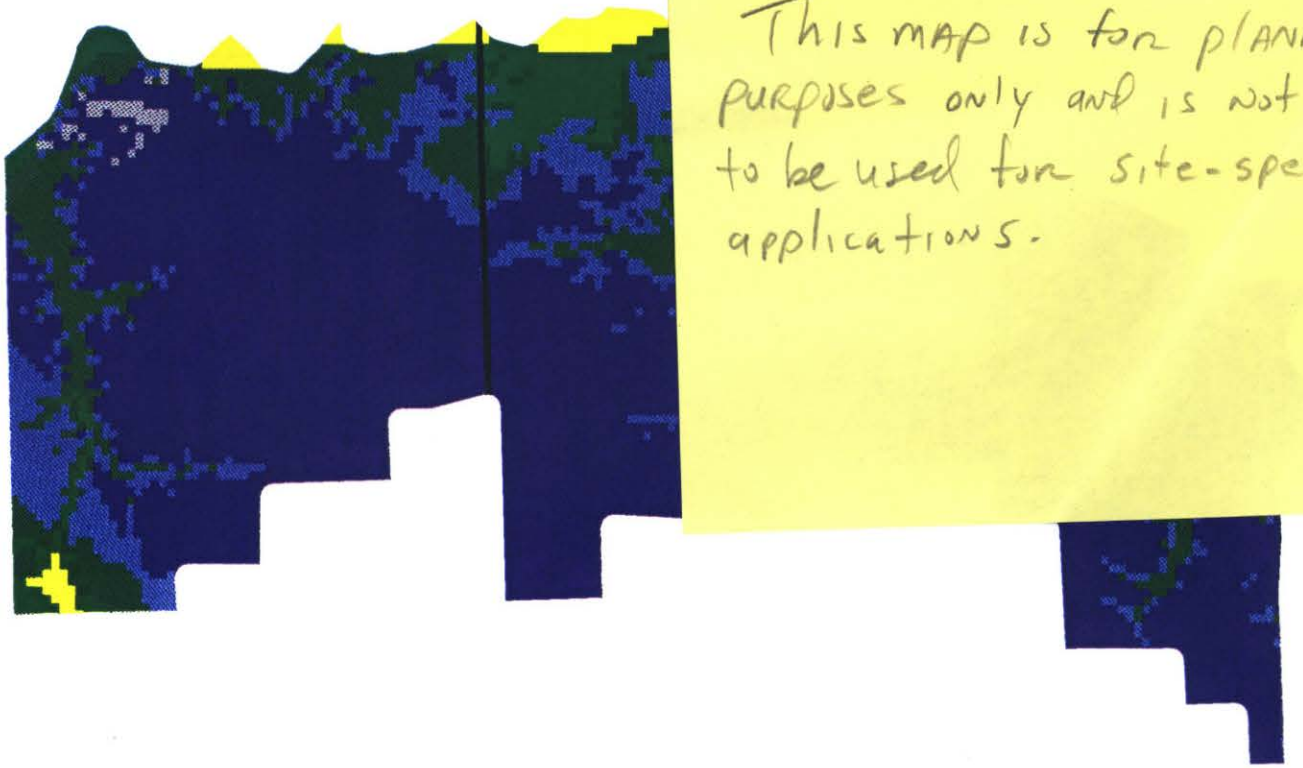
Limited information is available on Vadose Zone description. Sampling done in Knox county at 6 sites in 1990, sponsored by the

Groundwater Vulnerability to Contamination Using the DRASTIC Method

Lewis and Clark Natural Resource District

MAP 11

This map is for planning purposes only and is not intended to be used for site-specific applications.



Potential for Groundwater Contamination

low — high

Scale

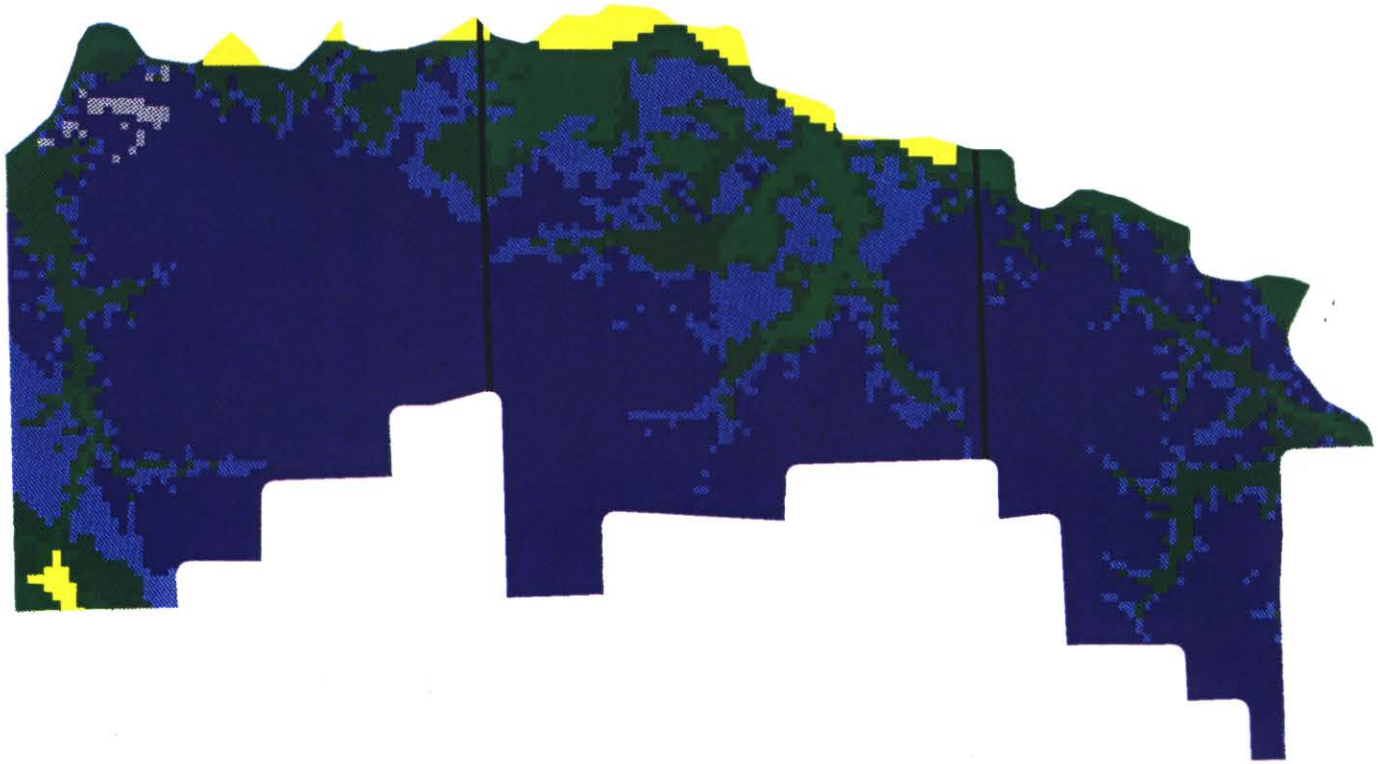
10 0 Miles

Source: CALMIT, Conservation and Survey Division

Groundwater Vulnerability to Contamination Using the DRASTIC Method

Lewis and Clark Natural Resource District

MAP 11



Potential for Groundwater Contamination

low — high

Scale

10 0 Miles

Source: CALMIT, Conservation and Survey Division

Lewis and Clark Natural Resources District, revealed significant amounts of nitrate-nitrogen at levels up to 28 feet deep. Total accumulated nitrate-nitrogen on one well was 1928# at 20'. The data was not conclusive to establish scope or trends however. Testing done in nearby Upper Elkhorn NRD in 1992 indicated vadose zone residual nitrogen levels at 5 times higher rates in irrigated cropland compared to unfertilized pasture. There is a need for more technical research into vadose zone impacts on groundwater quality as this can be termed a data deficiency. The NRD plans to look further into studies of this kind.

Irrigation usage has not increased significantly since 1986. At that time there were 509 total registered wells in the NRD, almost 10% ↑ that figure now stands at 558 (NRC 12/92). It is estimated that only about 8% of the acres of the NRD are presently irrigated based on NRC figures. (79,295 acres out of a total 933,660) Although 20% more acres could be irrigated from a soils standpoint, low yielding wells limit that capability, so that significant future irrigation growth is not considered likely.

Groundwater monitoring of static water levels continue to indicate insignificant fluctuation of water quantities (see table VIII). In the last 10 years, there has been less than 6 feet of variation in water tables and the trend is quite constant. If a 10% drop in baseline levels is observed over a 5 year period for a substantial area of the NRD this would be a basis for consideration of a management or control area. The district will consider all options legally available at that time to regulate usage and implement the most feasible methods to control depletion of aquifer supplies.

The district has investigated the presence of natural recharge areas and wetlands in the NRD. Maps obtained from US Fish and Wildlife service indicate most wetlands are in Riverine or Palustrine classification. The Riverine is in conjunction with the Missouri River and major tributaries such as Bazile Creek and Bow Creek; and the Palustrine covers mostly artificial impoundments found through out the grassland portions of the NRD. Investigation of Hydric soils of the NRD through UNL Conservation and Survey Division document that probably less than 3% or an estimate 26,400 acres of the District are sufficiently wet under undrained conditions to support hydrophytic vegetation. Hydric soils are an important factor for identifying wetland areas, but present information shows limited extent of such areas. The District believes recharge areas and wetlands presently make an insignificant impact on the management of groundwater. Additional data on this aspect may change that consideration.

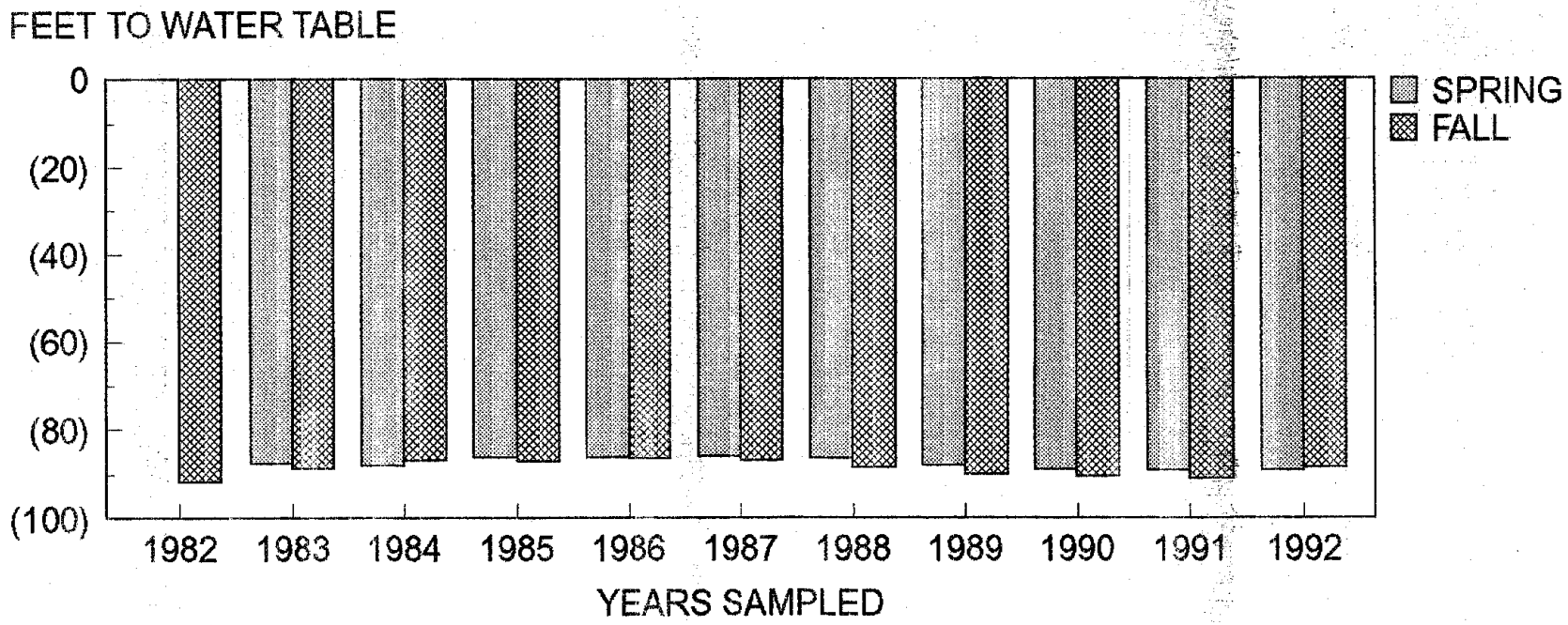
III. WATER QUALITY INVENTORY

The 1986 plan addressed the lack of an adequate water quality data base in the counties of Knox, Cedar and Dixon. In an effort to establish information on the concentration, scope, and trends of potential contaminants the Lewis & Clark NRD initiated a monitoring program in 1987. The first year testing sampled for the presence of nitrate-nitrogen, pesticides, herbicides, and volatile organic compounds. Altogether 19 chosen sites provided sample information

TABLE VIII

LEWIS & CLARK NRD

AVERAGE DEPTH TO WATER FROM 30 WELLS



that was analyzed for up to 76 potential contaminants each. Only three sites (16%) showed nitrate-nitrogen information exceeding 10 ppm and one site near Creighton showed Atrazine at .326 ppb. Follow up tests for atrazine showed no re-occurrence, and samples in successive years were taken for nitrate-nitrogen only. Annual sampling continues for nitrate-nitrogen and a pesticide scan as well has been rescheduled for 45 present sample sites in the NRD for groundwater quality data base (Map #12). Pesticide scans are planned to continue at 5 year intervals.

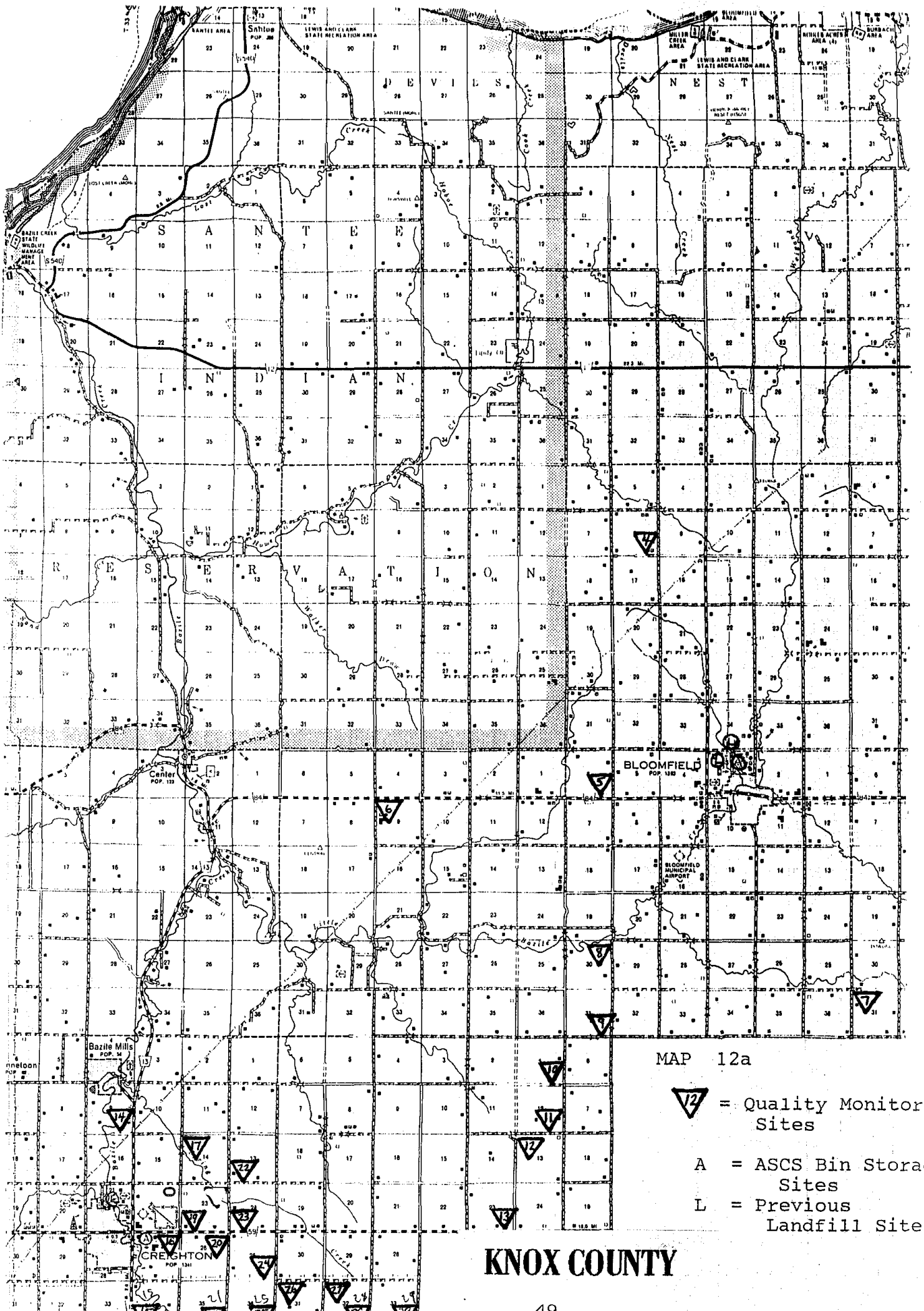
The NRD also started efforts in 1987 to utilize DEQ funding for an area of south central Knox County to determine additionalf data base information. The effort resulted in the cooperation of 3 other NRD's with other local agencies in the Bazile Triangle Groundwater Quality Study, 1990. Indications of the study which included 125 wells, showed 25% having nitrate-nitrogen greater than 10 ppm. In addition, the study revealed a likely connection of groundwater contamination with fertilizer-application practices. The study was inconclusive on the trends of contamination, however; so the Lewis & Clark NRD in Knox county continues to monitor nitrate-nitrogen concentrations annually.

Comparisons of local monitoring results between 1989 to 1990 and 1990-1991 have the same number of wells in the Bazile area decrease in nitrate-nitrogen levels, as increased. The average sample results taken in those two terms actually decreased for the Bazile Triangle location of south central Knox county. For reasons of excess rainfall in 1992, and the resulting non-activity of irrigation wells; no samples were taken that year.

All of the monitor wells are registered irrigation wells so that construction details can be considered in the results. Geologic data was examined at each site to originally select wells to obtain samples from the Pleistocene, Ogalalla and Niobrara Aquifer formations. Their locations were selected at random in 1987 and results documented (Table IX.) Sampling for nitrate-nitrogen followed training and procedures dictated by the Dept of Health lab who analyzes the data. Pesticide scans also follow prescribed methods to meet EPA requirements. Analysis scheduled for 1992 and postponed to 1993 will feature a Nebraska Scan of 12 pesticides and VOC's, as well as, nitrate-nitrogen. NRD personnel are certified as Water Well Monitoring Supervisors by Dept of Health.

The NRD also considered other information available to indicate the status of Water Quality. In reviewing EPA STORET groundwater quality data provided by NRC, Data Bank, it was found that much of that information was either included in the NRD's own information (Table IX) or of an age factor, (1935-1952) and quality control concern as to be questionable for valid use. The data does give some base information on nitrate-nitrogen levels. Average sample results were 3.3 for 50 samples with a range of 0 to 149 ppm.

Dept of Health in 1987 conducted a survey of domestic well water in counties of the NRD. That information was subsequently incorporated in Roy F. Spalding's report entitled "Assessment of Statewide Groundwater Quality Data for Domestic wells in Rural Nebraska." (1991). That report indicated ""about 26% of the



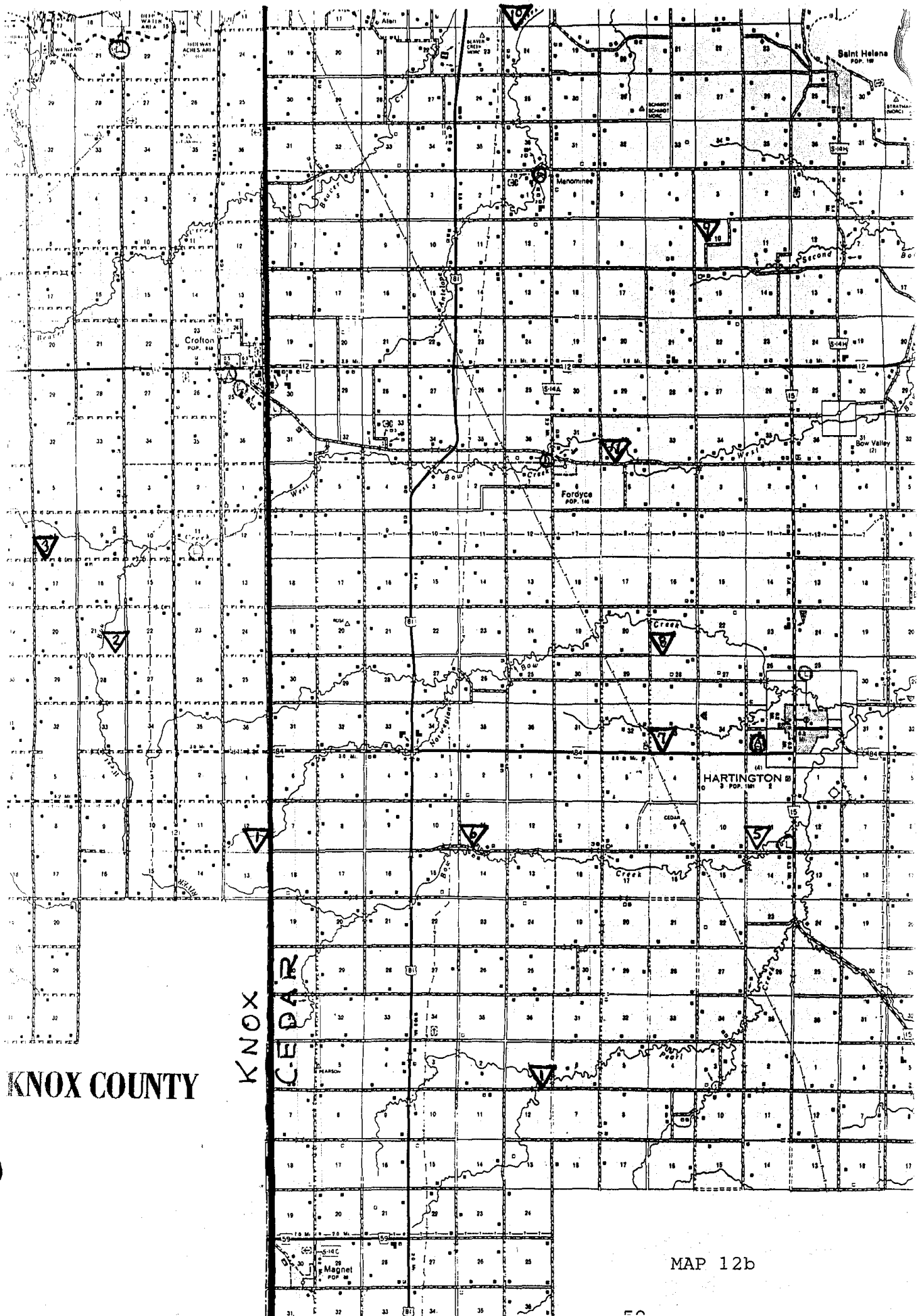
MAP 12a

▽ = Quality Monitor Sites

A = ASCS Bin Storage Sites

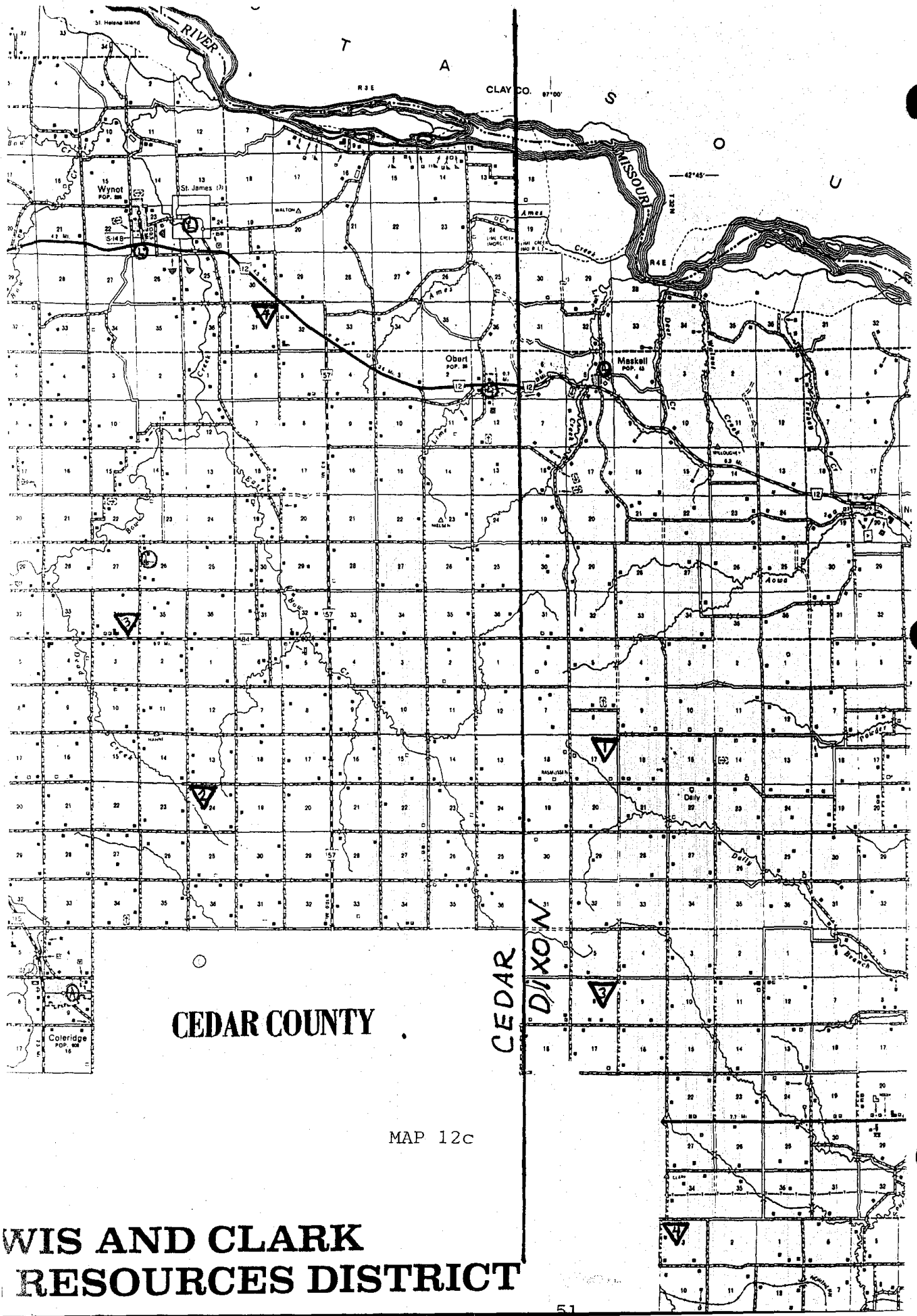
L = Previous Landfill Site

KNOX COUNTY



KNOX COUNTY

MAP 12b



MAP 12c

WIS AND CLARK
RESOURCES DISTRICT

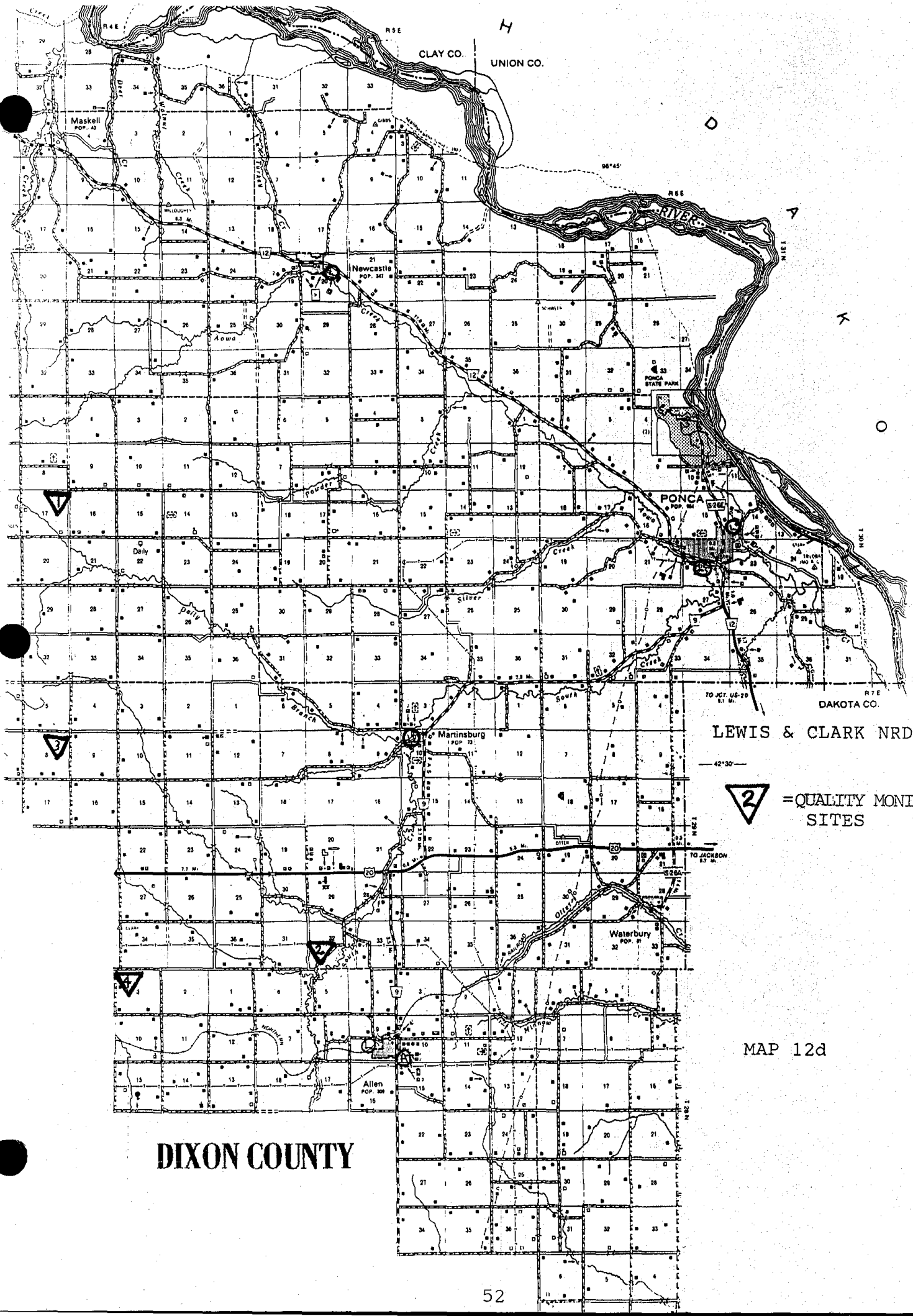

CLAY CO.
UNION CO.
DAKOTA CO.
Maskell
Newcastle
PONCA
PONCA STATE PARK
Daily
Martinsburg
Waterbury
Allen
RIVER
TO JCT. US-20
TO JACKSON
LEWIS & CLARK NRD
=QUALITY MONITO
SITES
MAP 12d
DIXON COUNTY

TABLE IX

GROUNDWATER QUALITY MONITORING RESULTS

Since 1987, the Lewis & Clark NRD has been sampling Groundwater at selected locations across the District. This information provides a data base to monitor changes in water quality. Site location was based on active irrigation wells having accessible collection points. These also gave well log data to determine aquifer characteristics including all but the Dakota Aquifer. Samples are taken in summer months by trained District personnel and submitted to State Dept of Health for analysis. Following their required procedures.

First year testing sampled for the presence of nitrate-nitrogen, pesticides, herbicides and volatile organic compounds. Since only nitrate-nitrogen concentrations were found to be of concern, sampling for other parameters are not done annually. Following are the results of nitrate-nitrogen levels found by years (1992 data incomplete). Locations of the numbers can be found on Map 13.

LOCATION	1987	1988	1989	1990	1991
DIXON CO					
D1 (Morton)	4.4	4.0	3.6	3.1	3.3
D2 (Haisch)	--	0.3	0.8	0.6	0.6
D3 (George)	1.8	0.2	0.5	0.4	0.4
D4 (Eckert)	--	3.9	5.1	6.0	6.6
CEDAR CO					
C1 (Arens)	--	7.9	9.7	7.8	10.6
C2 (Papenh)	4.0	5.1	7.7	8.1	4.4
C3 (Stone)	6.8	13.9	6.9	14.5	7.8
C4 (Kaiser)	--	0.8	0.5	0.9	1.4
C5 (Kathol)	<0.1	<0.1	<0.1	<0.1	<0.1
C6 (Lindeman)	1.9	0.2	0.1	2.3	0.2
C7 (Pick)	13.5	1.0	0.8	0.4	0.6
C8 (Seim)	0.9	0.6	0.4	0.4	0.4
C9 (Hoesing)	--	<0.1	<0.1	<0.1	<0.1
C10 (Zavadiil)	--	<0.1	<0.1	<0.1	<0.1
C11 (Sudbeck)	--	<0.1	<0.1	<0.1	<0.1

TABLE IX

GROUNDWATER QUALITY MONITORING RESULTS

Since 1987, the Lewis & Clark NRD has been sampling Groundwater at selected locations across the District. This information provides a data base to monitor changes in water quality. Site location was based on active irrigation wells having accessible collection points. These also gave well log data to determine aquifer characteristics including all but the Dakota Aquifer. Samples are taken in summer months by trained District personnel and submitted to State Dept of Health for analysis. Following their required procedures.

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CEDAR CO					
C1 (Arens)	--	7.9	9.7	7.8	10.6
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C3 (Stone)	6.8	13.9	6.9	14.5	7.8
C4 (Kaiser)	--	0.8	0.5	0.9	1.4
C5 (Kathol)	<0.1	<0.1	<0.1	<0.1	<0.1
C6 (Lindeman)	1.9	0.2	0.1	2.3	0.2
C7 (Pick)	13.5	1.0	0.8	0.4	0.6
C8 (Seim)	0.9	0.6	0.4	0.4	0.4
C9 (Hoesing)	--	<0.1	<0.1	<0.1	<0.1
C10 (Zavadiil)	--	<0.1	<0.1	<0.1	<0.1
C11 (Sudbeck)	--	<0.1	<0.1	<0.1	<0.1

KNOX CO	1987	1988	1989	1990	1991
K1 (Moline)	1.8	0.2	3.1	0.1	0.1
K2 (Hochstei)	15.5	15.5	15.8	15.9	17.2
K3 (Mackepra)	--	8.0	8.0	7.8	6.9
K4 (Braunsro)	--	<0.1	<0.1	<0.1	<0.1
K5 (Mills E)	4.0	3.0	2.8	2.5	2.9
K6 (Mills W)	--	4.4	4.9	5.9	5.9
K7 (Frevert)	<0.1	<0.1	<0.1	<0.1	<0.1
K8 (Doerr H)	--	--	--	9.9	0.2
K9 (Doerr Br)	--	--	10.3	10.5	11.3
K10 (Stevens)	--	--	8.2	7.3	7.0
K11 (Doerr K)	6.3	3.9	11.5	5.8	5.0
K12 (Ober D)	--	--	6.2	5.4	5.8
K13 (Doerr Bl)	--	--	19.6	8.6	8.3
K14 (Ober M)	7.7	6.7	6.6	4.3	4.2
K15 (Condon S)	3.8	3.6	4.2	4.4	4.5
K16 (Condon N)	6.4	7.0	8.0	9.1	7.8
K17 (Ebel)	--	--	13.6	18.1	15.6
K18 (Doerr D)	--	--	8.2	7.2	8.3
K19 (Hansen)	--	--	6.4	--	--
K20 (Paesl)	--	--	--	8.2	8.5
K21 (Fuchtm J)	--	--	8.4	17.6	17.3
K22 (Fuchtm K)	11.7	15.9	18.2	16.1	16.2
K23 (Doerr KS)	--	--	11.5	13.9	13.2
K24 (Rice)	--	--	8.0	7.4	8.3
K25 (Bartak)	--	--	16.4	12.2	15.6
K26 (McGill)	--	--	8.7	7.8	8.2
K27 (Eggerl)	--	--	4.1	--	--
K28 (Schlote)	--	--	11.3	13.4	11.2
K29 (Wostrel)	--	--	6.6	7.0	8.5

domestic wells in the eastern glaciated parts of Nebraska contained levels of nitrate-nitrogen exceeding the MCL." He further comments that concentrations are extremely varied within this glaciated area and that; "most contamination appears to be associated with point sources that are characteristic of older household and barnyard complexes." He theorized that as more of the old wells are replaced the incidence of high nitrate-nitrogen should decrease. Spalding also noted high correlations of nitrate-nitrogen to bacteria in northeast Nebraska. The area also had a rather high occurrence of gross alpha activity which indicates a uranium concentration in the soil. These both may be issues for future consideration as data deficiency items but are not a priority concern at this time.

As a further effort to build on base data available, the NRD is also considering the prospects of getting updated test sampling of the locations listed in Table IV (original plan). The 1978 data included a wide spectrum of parameters, however many of the sample sites no longer exist as producing wells. The district plans to research the location information to see where current data may be obtainable.

IV. LAND USE AND CONTAMINATION SOURCE INVENTORY

A. Land Use

Digitized Land Use Surveys are not available for the Lewis & Clark NRD as of this writing. When they become available the NRD intends to examine the impact land use has on areas of recharge and potential contamination locations.

B. Contamination Source Inventory

Non-point

Residential areas are limited in Lewis & Clark NRD so that almost all non-point source contamination comes from Agricultural activity. From Spaldings Report (1991), and based on the Bazile Triangle Study (1990), the most likely source is fertilizer-manure application practices together with over watering of irrigated crops. Documentation on exactly where this is occurring is presently speculative until monitoring efforts indicate concentration increases. It is worth noting however that fertilizer consumption in Nebraska is on the increase in the last 5 years. Almost 1.9 million ton was sold in the state in 1990. Cedar County has 9,250 ton. Dixon County has 2,085 ton and Knox County 9,968 ton (ref Ag Statistics, 1990). Location of large fertilizer storage sites has been noted by means of director surveys. (Map 13)

Point Source

The Dept of Environmental Quality has provided this NRD with a listing of current point source activity (1992). What follows is a summary of those locations and type of activity in the Lewis & Clark NRD:

1. Wellhead Protection Areas

Delineated by DEQ at Creighton, Waterbury, Newcastle, and Maskell. The Lewis and Clark NRD continues to assist those communities on this.

2. Feedlots

Exact locations are available but there are currently 7 in Knox County, 14 in Cedar County, and 4 in Dixon County. An area west of Bloomfield has a concentrated area of 3 hog confinements and egg production facility. The area warrants future consideration for expanded monitoring activity.

3. Hazardous Waste Site (RCRIS)

Seven locations in the NRD are presently registered with EPA to deal with hazardous substances; either to generate, store or for transporting. They are Hesse, Inc, and Sexauer Co., Crofton, NE; Hydraulic Components Industry, Hartington, NE; George Van Cleave, Allen, Bloomfield Monitor, Bloomfield, Robert Youst, Coleridge, and Northland Transportation Inc, Magnet.

4. Hazardous Substance Storage

The Emergency Planning and Community Right to Know Act lists businesses that use, store, or release hazardous substances. There are 14 listed community locations for storage of pesticides: Allen, Bloomfield (2), Coleridge (2), Creighton, Fordyce, Hartington (3), Magnet, Newcastle, Ponca and Wynot.

There are also 28 locations where petroleum products are stored. They include all of the previous listed towns plus Crofton and St. Helena.

5. Leaking Underground Storage Tanks (LUST Sites)

A 1992 listing of all leaking underground storage tanks lists 10 locations in the Lewis & Clark NRD. In all cases the leaking product was identified as either gasoline, diesel fuel or waste oil. Those sites by community include: Allen, Bloomfield, Coleridge, Creighton (6), Crofton, Hartington (3), Newcastle, Magnet, Ponca (3), and Wynot.

6. EPA Hazardous Substance Spill Site (CERCLIS)

There are two locations in the NRD which state and federal authorities have identified as being contaminated with a hazardous substance under the Comprehensive Environmental Response Compensation and Liability Information System. They include George Van Cleave of Allen, NE and Village of Fordcye, Fordyce, NE.

7. Landfills

Most landfills in the District are being closed or have been at this time based on information provided by DEQ. Fordyce and Magnet have closed and Creighton and Hartington area in the process. Landfills at St Helena and Newcastle are unlicensed and presently scheduled for additional study. The only licensed landfill remaining in the NRD is, Arens Sanitation, near Crofton. It has a listed design of 12 acres and a life span of 35 years. Plans are underway at Hartington to locate a Central Transfer Station to receive garbage for re-transport to the LB Gill licensed landfill located at Jackson, NE. Several communities are expected to cooperate in this method of disposal.

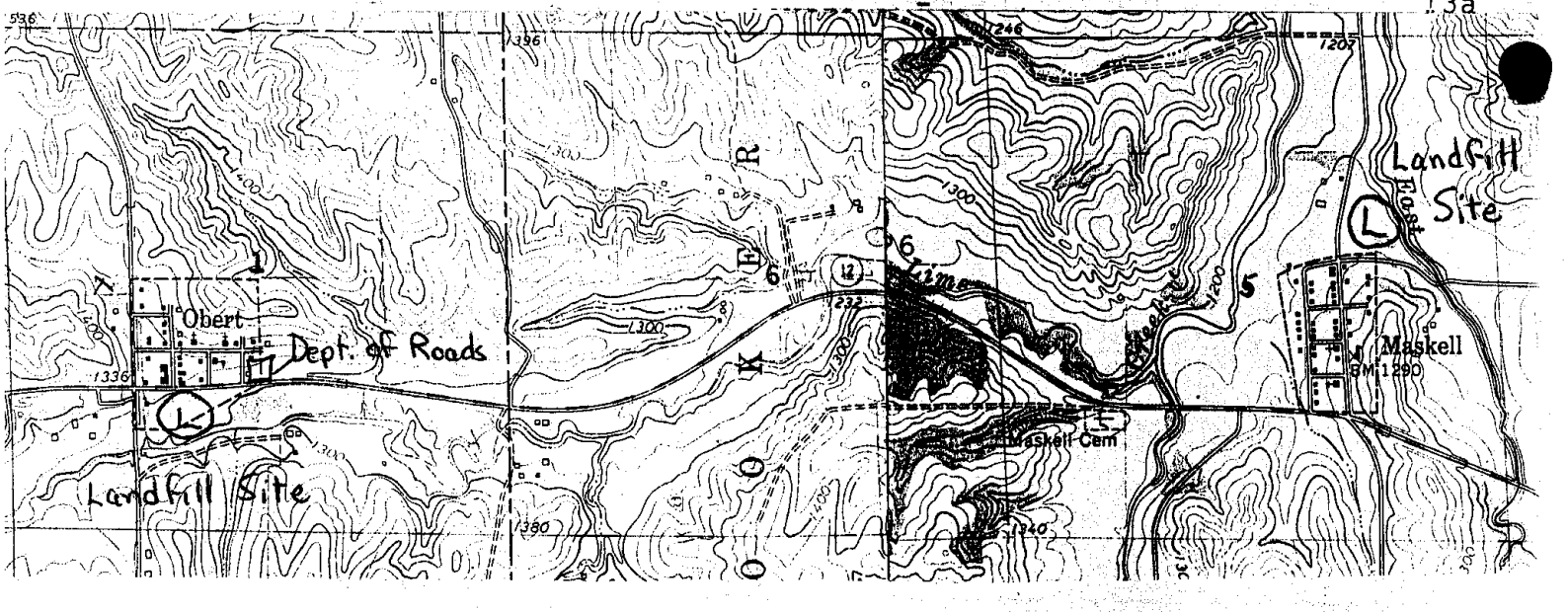
8. NPDES Permits

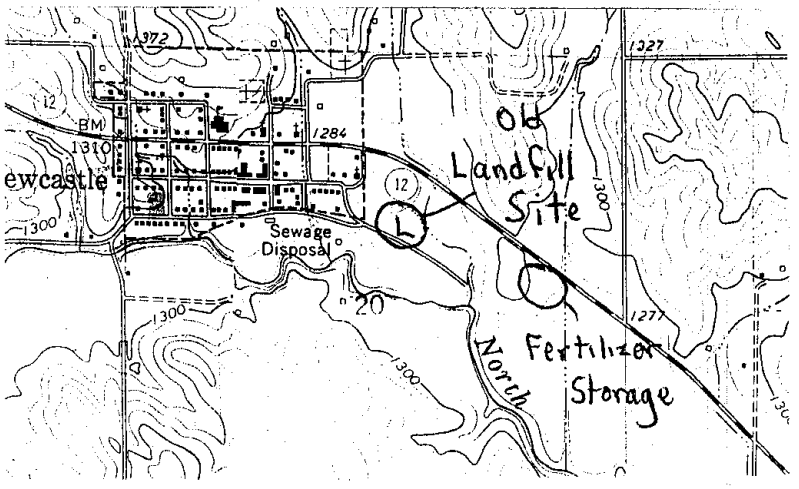
National Pollution Discharge Elimination System permits have been issued to 19 facilities in the NRD, 12 of these are for Waste Water Treatment Facilities of local communities. The others related to individual discharge facilities that provide annual reports to DEQ.

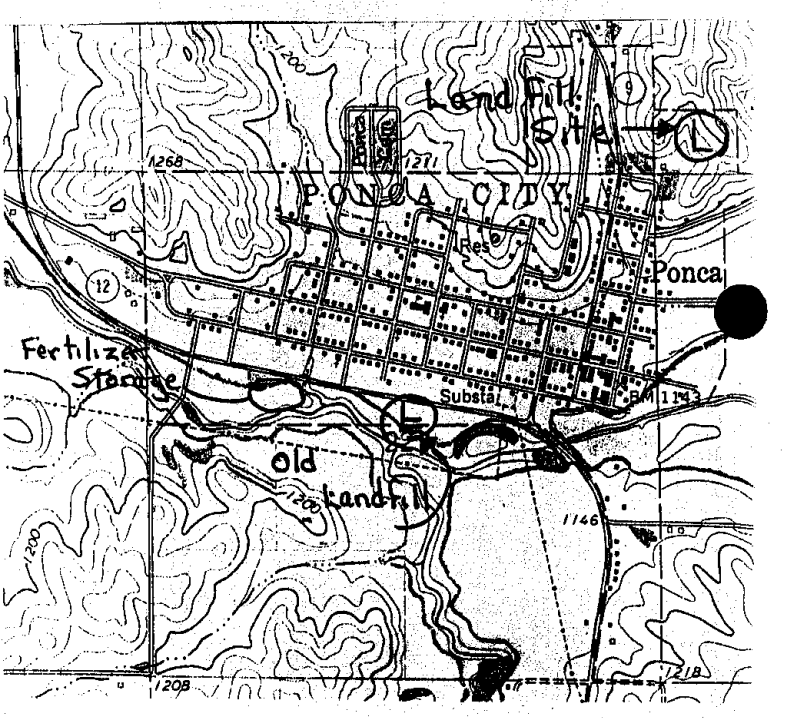
DIXON COUNTY

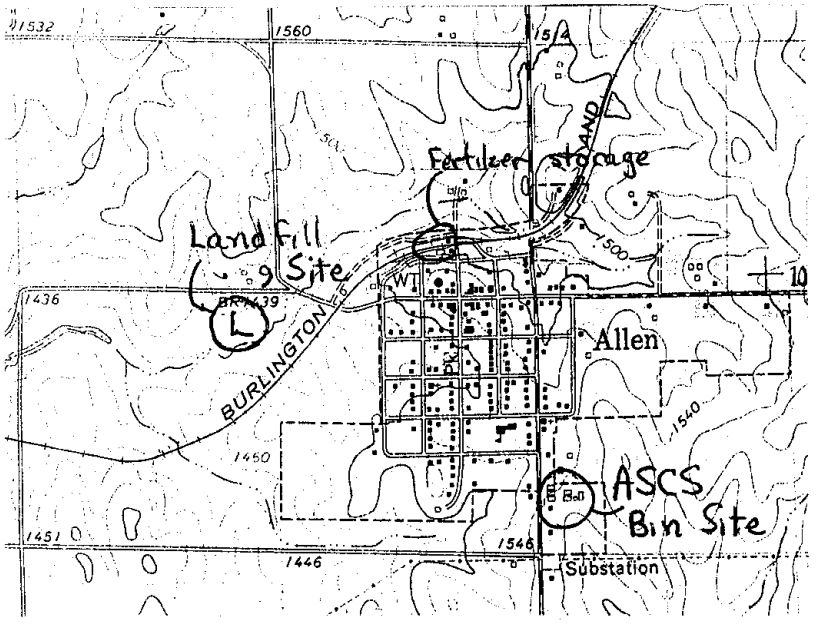
INVENTORY OF POINT SOURCE LOCATIONS
-1993-

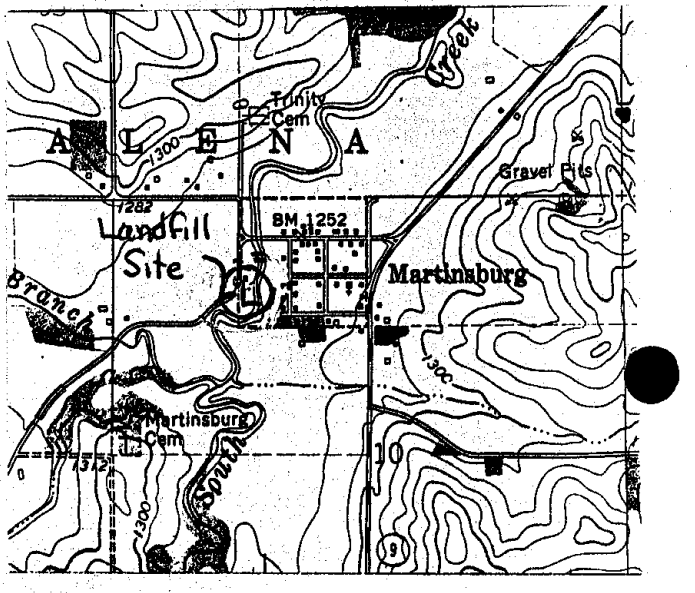
13a



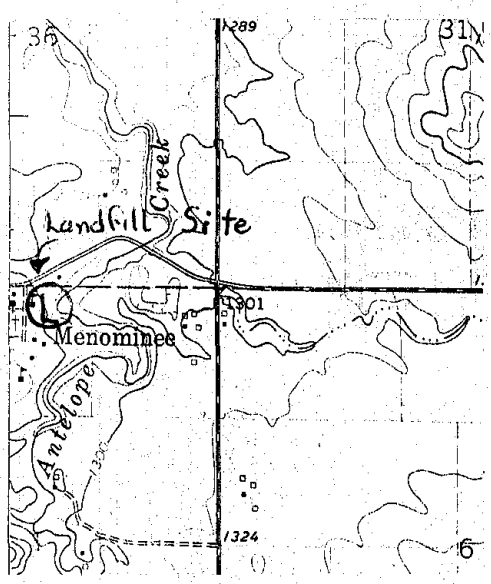


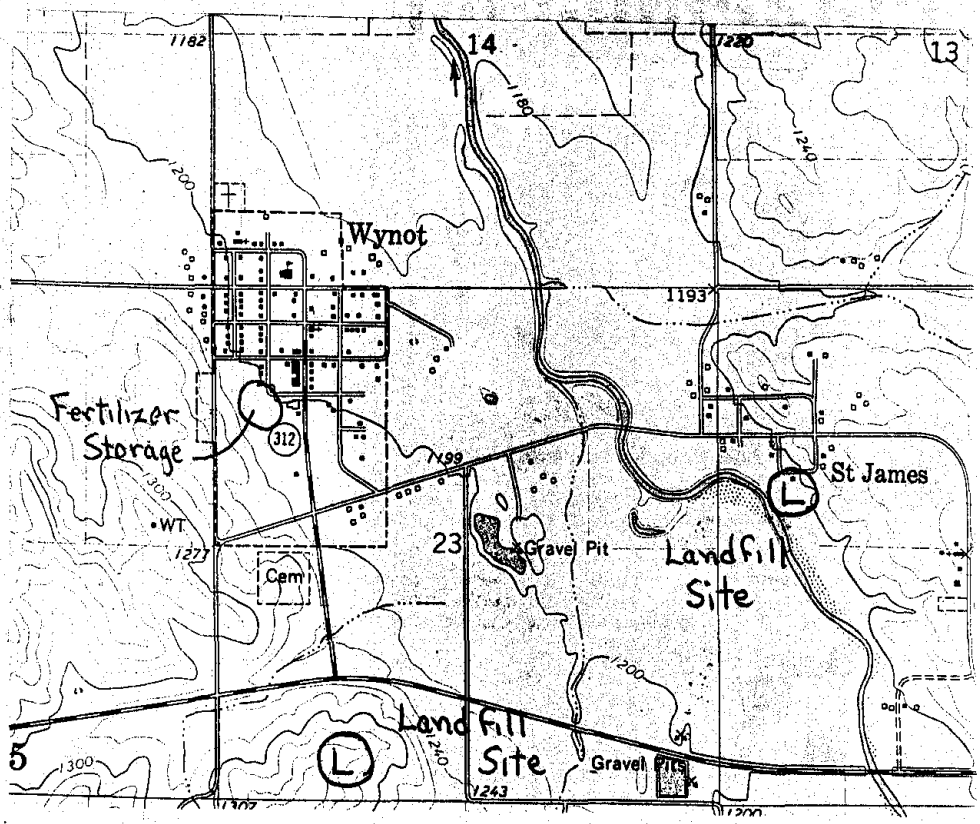


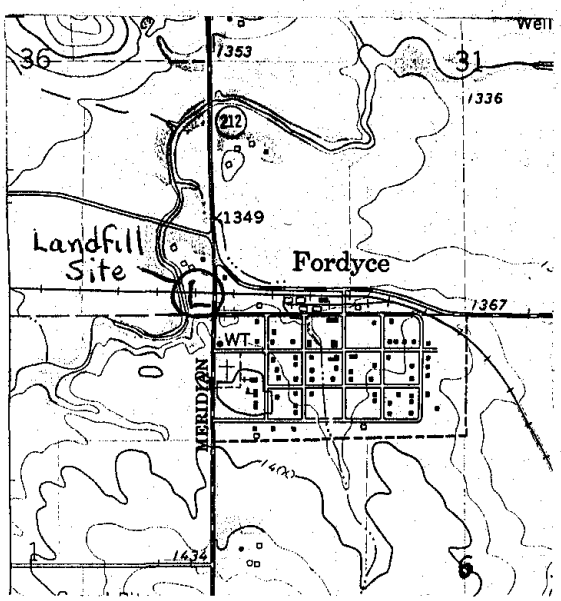


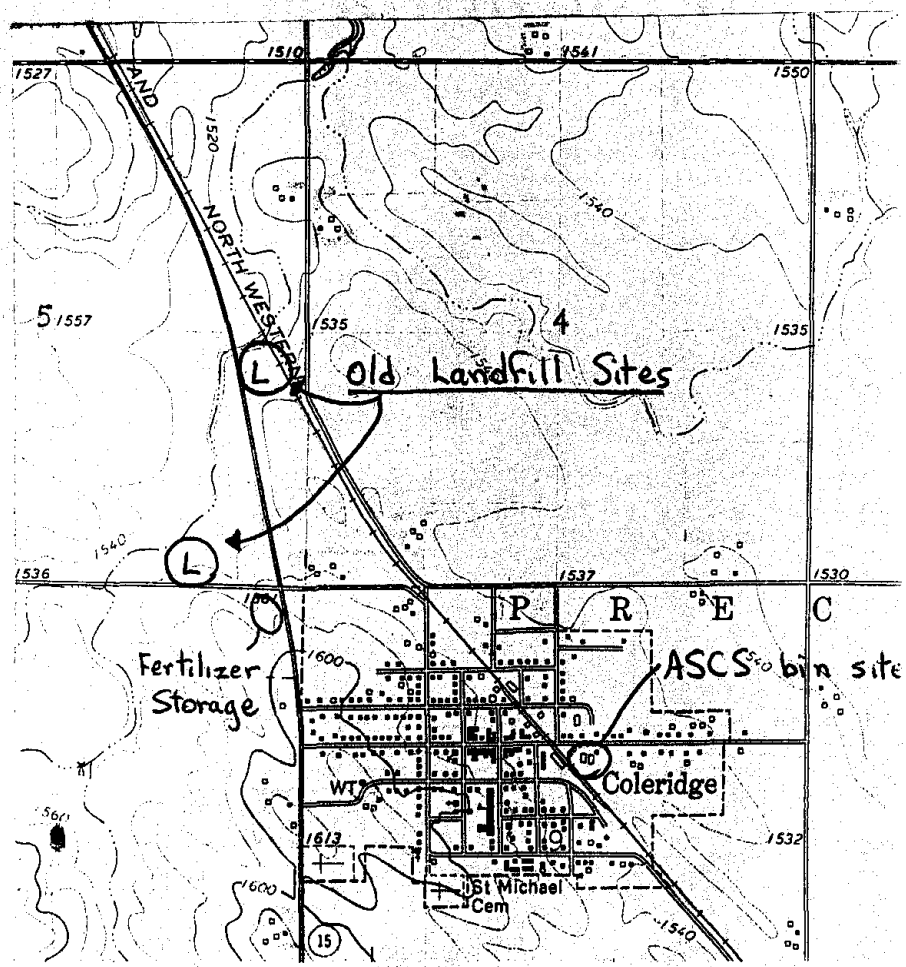


CEDAR COUNTY

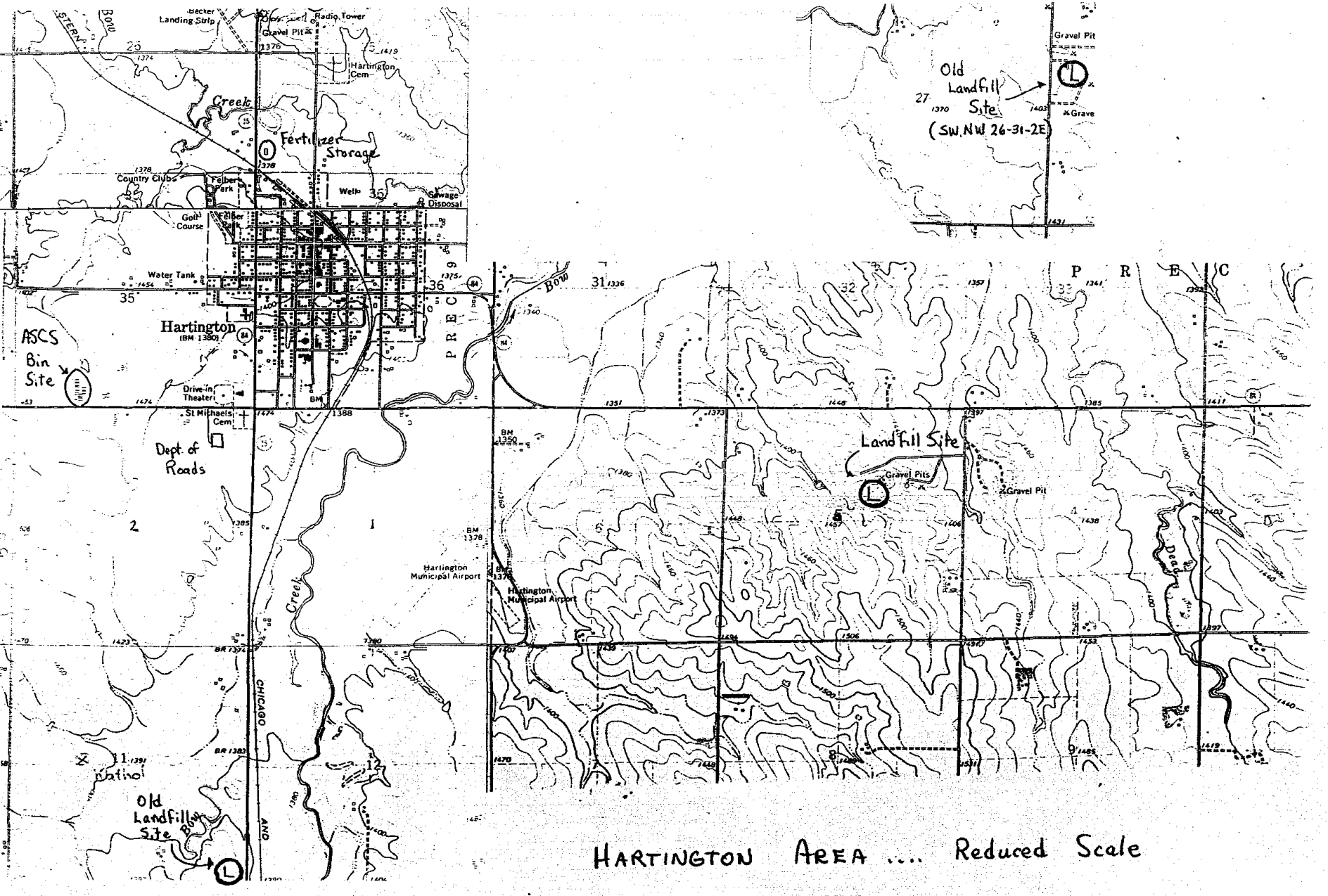






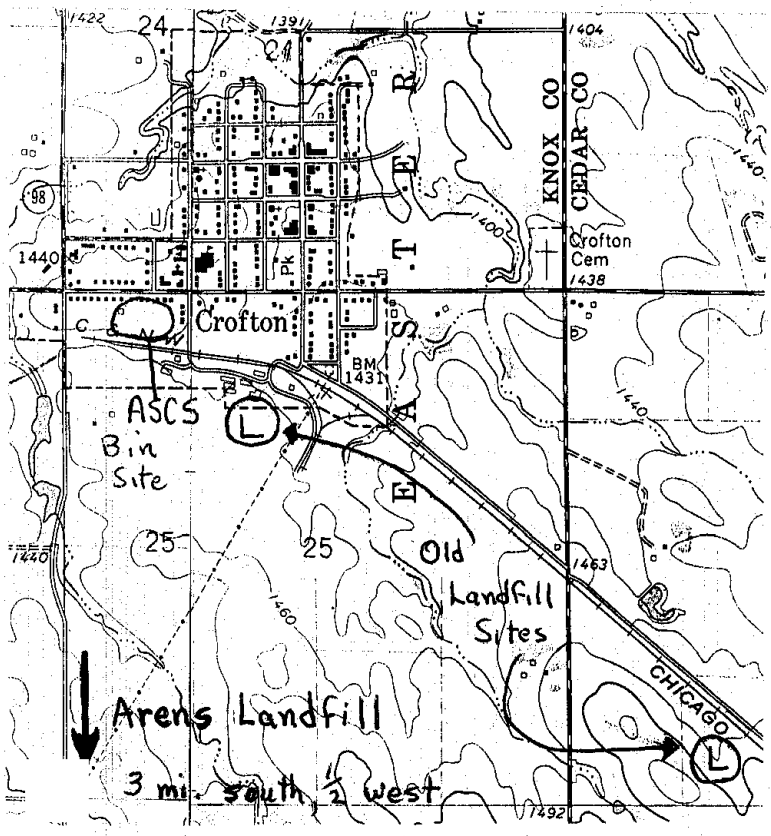


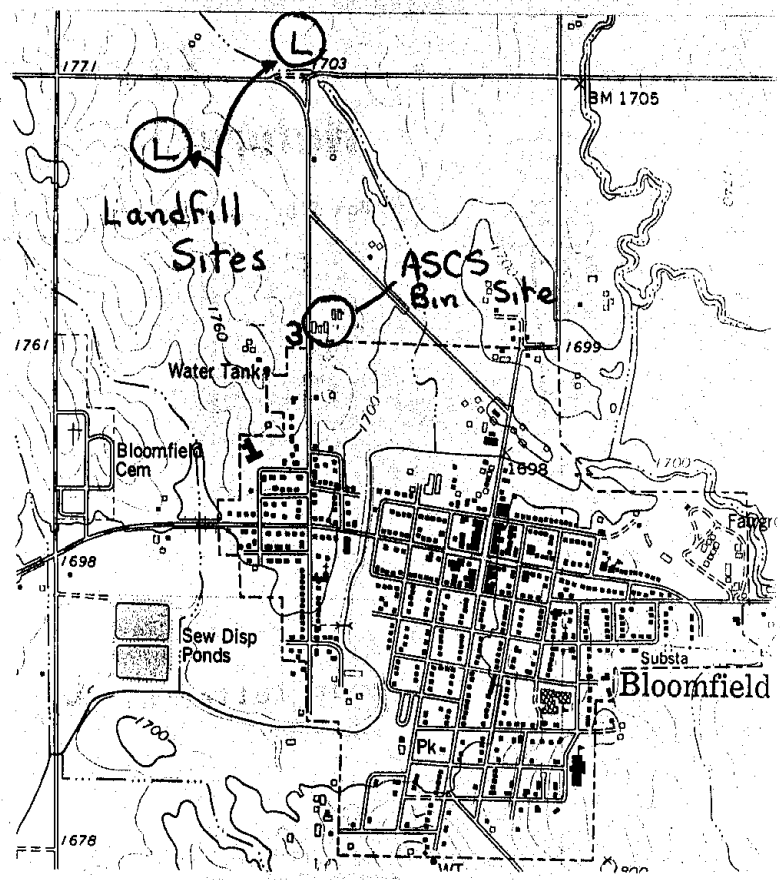
CEDAR COUNTY HARTINGTON

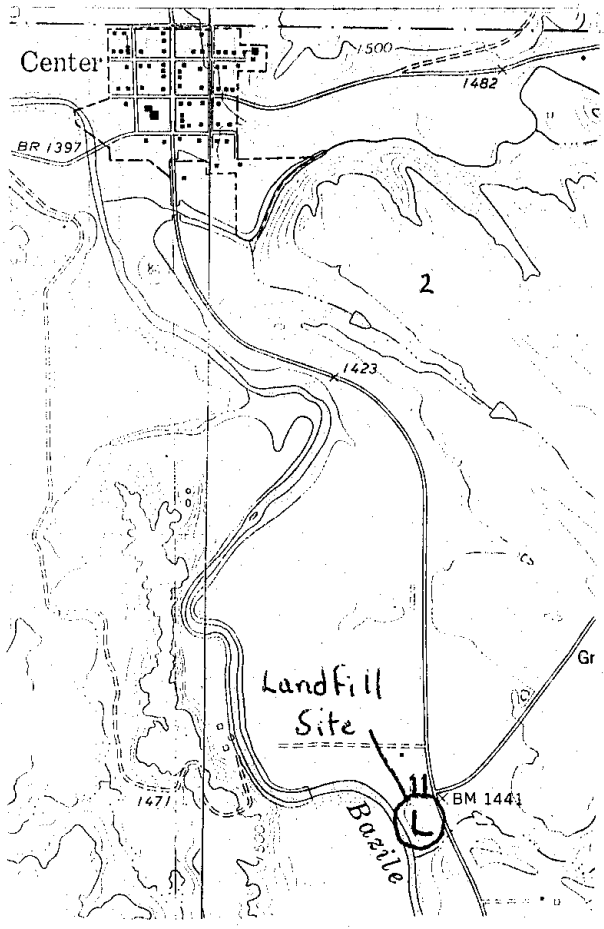


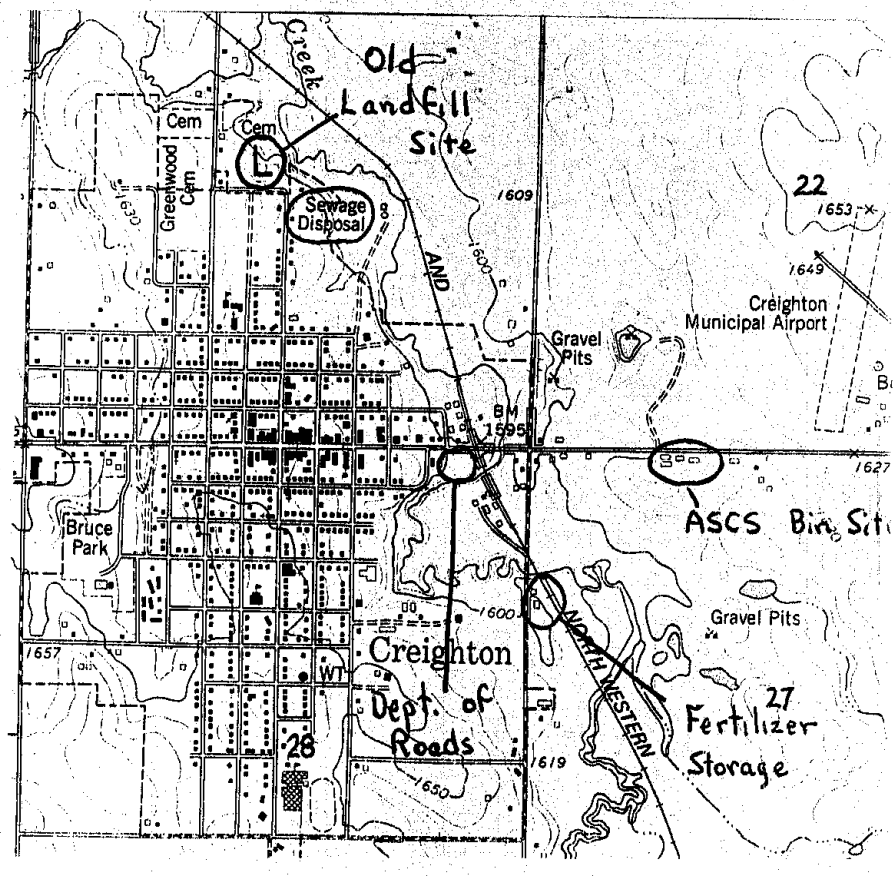
HARTINGTON AREA .... Reduced Scale

KNOX COUNTY


Crofton
ASCS Bin Site
Old Landfill Sites
Arens Landfill
3 mi. south, ½ west
KNOX CO
CEDAR CO
Crofton Cem
CHICAGO


Landfill Sites
ASCS Bin Site
Water Tank
Bloomfield Cem
Sew Disp Ponds
Bloomfield
BM 1705


Center
Landfill Site
Basile
BM 1441


Old Landfill Site
Cem
Greenwood Cem
Sewage Disposal
Creighton Municipal Airport
Gravel Pits
Bruce Park
ASCS Bin Site
Creighton Dept. of Roads
Fertilizer Storage
NORTHWESTERN

9. ASCS Grain Storage Sites

By utilization of NRD director participation survey, the NRD has located six former ASCS grain bin storage sites. The presences of Carbon Tetrachloride in groundwater at Bloomfield and other state locations have raised the issue of possible future concern. These locations are noted for the record on Map 13.

V. WATER USAGE AND DEMAND

Groundwater usage in the Lewis & Clark NRD primarily goes to domestic and agricultural use. As discussed in the original Groundwater plan. Aquifer characteristics allow limited availability of groundwater supplies and static water levels have remained fairly constant (Table VIII). Outside of relatively high naturally occurring total dissolved solids, groundwater in the NRD is generally suitable for current and potential use.

Population Density has declined in the Lewis & Clark NRD over the last 10 years. NRD population by 1990 census was 16,572 compared to 19,428 in 1980. That represents about a 15% decline. Comparisons of municipalities alone show the same proportion, so that the decline can be described as uniform across the entire NRD, regardless of rural-urban associations. Water use by municipalities, from limited information collected by UNL Conservation and Survey and USGS, does not reflect significant trends in comparison since 1980. Not enough information is available to adequately project if municipal usage is increasing or decreasing as this is an area of data deficiency among state agencies.

Future demand for domestic water will likely not increase for population requirements. It can be expected however that if groundwater quality declines, some communities as well as private individuals will be looking for alternate sources of water or treatment of existing sources. Such problems have already occurred at Creighton, NE which has installed a water treatment plant for nitrate removal. For like reasons Obert has contracted to the Lewis & Clark NRD - Cedar Knox Rural Water Project to join with St. Helena which also depends 100% on rural water as a source. Crofton supplements their wells at present with rural water. All other communities in the NRD presently depend on groundwater wells as their source of drinking water. Expansion situations of the rural water project to serve other communities is not anticipated except in limited situations, so that future quality concerns will likely need to be dealt with by municipal treatment methods. Bazile Mills and Waterbury are two communities that are working on decisions for nitrate-nitrogen alternatives. The NRD continues to assist those communities that encounter such problems.

Agricultural usage through irrigation remains at a constant level. In 1985 there were 509 total registered wells. In 1992, that total increased to 558, an increase of 9.6% Current SCS figures show total irrigatable acres represent 8% of the cropland in the NRD. Most of irrigation is applied through center pivot systems and because of aquifer characteristics limiting

availability, the location of that irrigation is predominantly on southern portions of the NRD (Map #14). No control or management areas presently are established that require metering. Consequently, data on specific gallons pumped is not available. Future growth and additional demand for Groundwater irrigation is not expected to be significant, simply because of aquifer limitations.

Water usage and demand by industrial, fish and wildlife, and recreation is not expected to change significantly; nor are they presently impacted greatly by groundwater quality in the Lewis & Clark NRD.

Analysis of impacts on endangered or threatened species have been considered. According to the Nebraska Game & Parks Commission the only species that might presently be located in habitat of the Lewis & Clark NRD is the Western Prairie Fringed Orchid. No technical data is available to identify negative impacts on this or any other presently known endangered or threatened species by planned groundwater management activity. Coordination with the Nebraska Game & Parks is anticipated to locate habitat sites that may be suitable for the Orchid or other species. The procedure for addressing endangered and threatened species shall follow four prescribed steps.

1. Recognition of the existence and/or potential existence of threatened species that may be affected by groundwater levels. At this time only Western Prairie Fringed Orchid is thought to be present in the Lewis & Clark NRD

2. Recognition that general protection of groundwater quantity and quality has many benefits including protecting the habitats of threatened species.

3. Recognition that any groundwater management activities proposed in the plan may have some impact (positive or negative) on threatened species listed in the plan.

4. Should specific adverse effects on threatened species from changing groundwater levels be identified the NRD acknowledges the potential need to modify groundwater management plans in the future. Such modifications should include actions within control or management areas consistent with the Nebraska Groundwater Management and Protection Act that could be taken by the NRDs to reduce adverse effects on species by maintaining a groundwater level that will help sustain these species.

VI. IDENTIFICATION OF CRITICAL AREAS

To come to a consensus of groundwater contamination risk, it is necessary to again review the physical characteristics of the Lewis and Clark NRD. Located in the northeast corner of the

NEBRASKA NATURAL RESOURCES COMMISSION

DATA BANK

LEWIS AND CLARK

NATURAL RESOURCES DISTRICT

CENTER PIVOTS LOCATION MAP

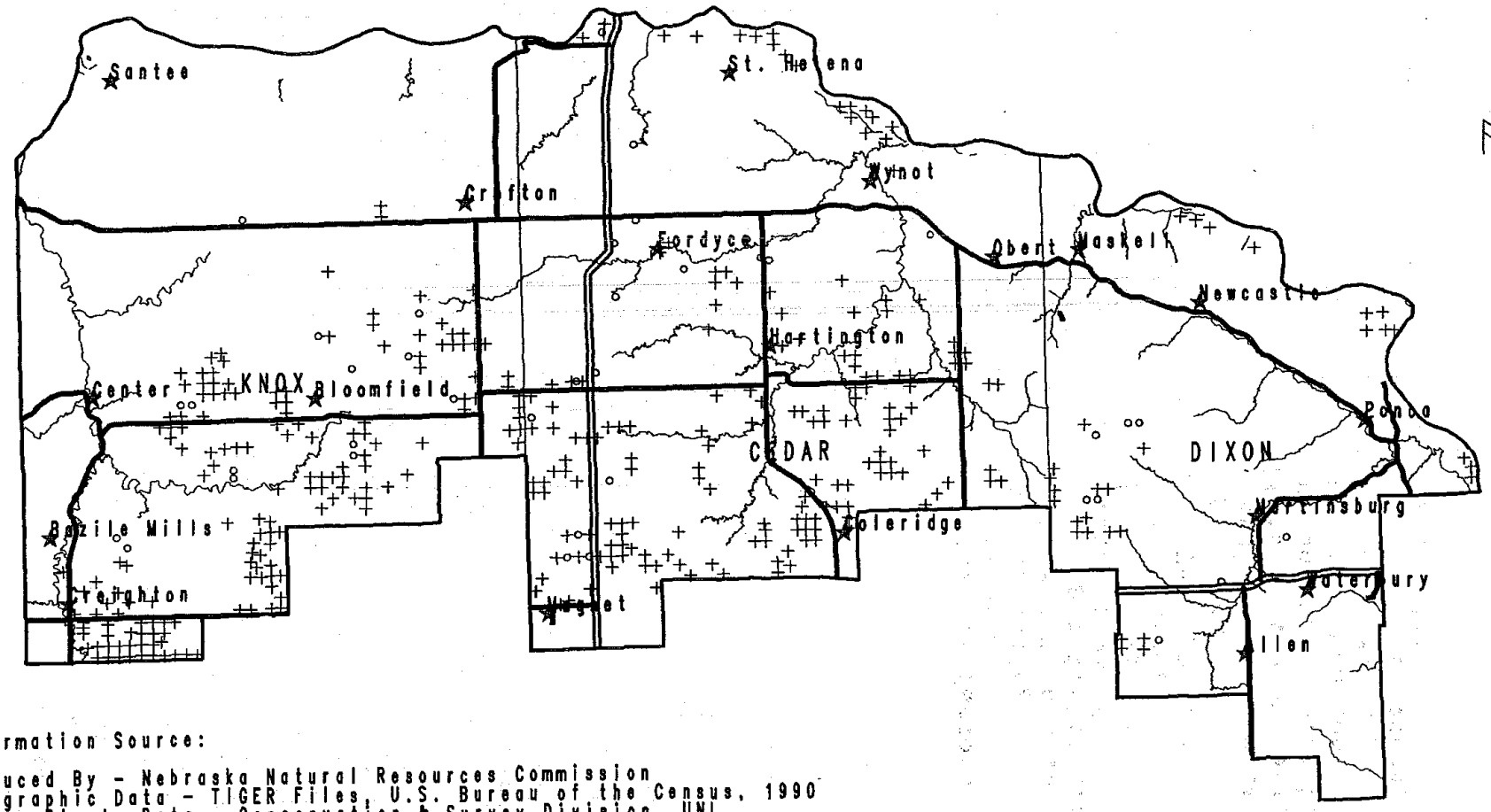
LEGEND

MAP #14

Scale 1:500,000

4 0 4 8 12 16 20 Miles

+ Pivots sighted in 1988
o Pivots not sighted in 1988
Interstates and Primary Highways
U.S. and State Highways
Perennial Streams and Canals



Information Source:

Produced By - Nebraska Natural Resources Commission
Topographic Data - TIGER Files, U.S. Bureau of the Census, 1990
Center Pivots Data - Conservation & Survey Division, UNL.
Database updated through Dec. 1988

GIS Process - ARC/INFO
Processed - March, 1993

The District has some areas of concerns that warrant continued or intensive monitoring. One of those areas is around Creighton. That area was the subject of an intensive groundwater study in 1989; (reference Bazile Triangle Groundwater Quality Study Paper #68 UNL Conservation & Survey). The study indicated that 25% of the irrigation well samples had nitrate-nitrogen levels exceeding the MCL. In the study conclusions however, the author states, "There is insufficient data to implement a specific groundwater management or protection strategy even though the groundwater appears to be contaminated to varying degrees." Subsequent annual sampling activity since 1989 have not identified significant trends. This part of the District will be the focus of continued monitoring and already has been targeted by USDA as part of the Bazile Triangle WQSP. As such it qualifies for special cost share eligibility through ASCS including long term agreements. ACP cost share, WC-4 and SP53. Part of east-central Cedar County and west-central Dixon County may also be considered as potential indicator zones, and will continue to be monitored.

Land uses in the areas mentioned previously may have a significant impact on groundwater quality. in the Lewis & Clark NRD, contamination of groundwater is most likely to occur in non-point source cases from fertilizer over application (ref. Gosselin, 1991), and in point source situations from poorly constructed wells (ref Spalding Study, 1991). Based on that premise, both existing and future cropland areas of the District, which receive the bulk of fertilizer activity, bears watching. That cropland base is not likely to expand, nor is the area population. Groundwater quality, however, may still decline without attention in those cases. as leaching continue to occur under both contaminated and natural conditions.

Quantity depletion is not expected to be a current or future impact on groundwater quality unless unknown factors intercede on present situations.

VII. GROUNDWATER QUALITY GOALS AND OBJECTIVES

The District recognizes that it cannot control all factors that lead to an increase in nitrate nitrogen or other contaminates in groundwater. Climatic conditions, cropping practices, and natural breakdown of organic residue can lead to leached contaminates that would occur even with proper fertilizer application, for example. Consequently, the District would prefer a holistic approach to preserve the natural quality of groundwater by an educated management effort that includes consideration of all best management practices. The NRD feels this can best be accomplished by voluntary cooperation of landowners until scope and trends indicate otherwise. The basis for this position rests in the fact that aquifers in the NRD area not homogenous. Generalized control area solutions that would be appropriate to heavily irrigated, consistent aquifer locations in Nebraska would not necessarily fit Northeast Nebraska where irrigation is less than 10% and contamination from point source, is as likely as non-point source because of the aquifer variability.

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Based on the limited hydrogeologic information available, the Lewis & Clark NRD's goal is; "to maintain infinitely the natural quality of groundwater sufficient for all beneficial uses of the water and below current established federal maximum contaminant levels (MCL's). Modified objectives developed locally through public discussion at NRD board meetings has evolved to; first, monitor and identify problem areas, and secondly, carry out voluntary preventative programs and practices to address those problems. Third, should trends become apparent that identify problems that exceed maximum contaminant levels, the board shall take steps to set boundaries and establish groundwater management or special protection areas, to institute regulatory steps as necessary. The process of accomplishing this shall be defined in Phases. Phase I and II relate to ongoing District programs or intensified efforts. Phase III involves official designation of a Groundwater Management area based on the NRD "Scope and Trends" factor to be defined here. (TABLE X)

REVIEW OF OBJECTIVES

PHASE I. Monitor and identify problem areas

The areas of concern for water quality continue to be those shown on Map 10 and have been the focus of existing programs. Although no significant trends have been established, data collection continues in order to monitor quality status and will be expanded as the need arises. Additional study, for example, may be necessary to evaluate seasonal variations or the extent of contaminant stratification, to determine details on the hydrogeologic system. The NRD uses irrigation wells for locating areas of concern because of the reliable data available in registered well logs. Monitoring efforts are intensified if test results indicate increasing trends following Phase II procedures.

PHASE II. Voluntary Preventative Programs

Many of the authorities of a declared management or special protection area are available to implement voluntarily prior to

such declaration. Preventative groundwater quality programs that will be reviewed in Section VIII are already underway in the NRD. Concentrated efforts are focused on areas where contaminant levels have reached 50% of their MCL limits. Voluntary methods will continue and intensify at that time to include additional monitoring wells. The District will strive to add wells within 2 miles for each suspect well that show concerning results for two consecutive years. Preventative Programs in Phase II will be funded at 100% and Educational public meetings will be planned. Specific efforts will be undertaken with Conservation & Survey staff to determine within 6 months if test results are being contaminated from non-point or point sources (point sources are exempted from this Phase consideration and will be referred to DEQ). Additional studies to determine aquifer consideration depth to water, direction of flow, soils and water use development may be desirable. The District may seek study and declaration of a Special Protection Area by DEQ if that option appears more effective at that time.

PHASE III. Groundwater Management Area based on Scope and Trends

Official designation and regulatory actions for water quality will be established when contaminant levels and annual trends indicate the need. This process we will call the "Scope and Trends" factor which is defined as when 50% of the groundwater samples taken over a large area show an increasing trend for 3 years that reaches 90% of the MCL. The NRD will then define boundaries for the described area, which unless determined to be less by the NRD board, shall be a minimum of 18 square miles. For example, if nine or more individual wells within an 18 square mile area show a 3 year upward trend on testing results, that reach or sustain a level of 90% of the MCL for any contaminant determined to be from a non point source; the NRD will within 1 year establish boundaries along section lines based on Phase II studies. If for some reason trend factors increase substantially on less than 50% of the wells, the District reserves the right to still initiate designation and regulatory actions if it feels that to be appropriate. Specific actions in addition to Phase II Efforts shall include the following:

Phase III Management Action Tools

1. Restriction on fall fertilizer applications
2. Certification by area farmers on irrigation and fertilizer management.
3. Requiring "Best Management Practices" (irrigation scheduling, timing of fertilizer and pesticide application and other management programs
4. Require annual analysis of groundwater and deep soils samples for fertilizer and chemical content
5. Annual reports by area farmers on management activity.

As mentioned previously, only 8% of the District areas are under irrigaton. However, if extensive irrigation use is determined to be a factor, additional tools to implement a Groundwater Management Area would include:

1. Required use of flow meters and monitoring equipment
2. Allocation of water on an acre-inch basis
3. Rotation system of water usage
4. Well spacing requirements
5. Reduction of irrigated acres.

VIII. GROUNDWATER QUALITY PROGRAMS AND PRACTICES

The Lewis and Clark NRD believes in preventative programs to the point where conditions are not reversible otherwise. In a risk assessment-risk management determination in 1993, the District concluded that voluntary compliance is an effective way to address current problems in the District because cooperation has been positive and affected areas are relatively small. Further, many general programs that would be part of a management area package already are now being utilized throughout the District on a voluntary basis. They include:

1. Deep Soil Testing Cost Share Program

District pays 75% of actual costs for samples taken to 3 foot depth and analyzed for residual nitrogen. 320 acre limit established per cooperator. Copies of results and billing are required for payment. Annual participation is about 50 cooperators per year at a NRD cost of $10,000. Since the program was started in 1990, results have shown a considerable drop in average residual nitrogen.

2. Sealed Well Abandonment Program S.W.A.P.

Inverse cost share program to encourage proper plugging of abandoned wells. District takes $50 application fee and then contracts by annual bid to licensed well drillers to properly close off well sites. Annual participation is about 50 cooperators per year at a NRD cost of $10,000.

3. Wellhead Assistance Program

Work with local communities by offering the previously mentioned programs and establishing protection plans in cooperation with Dept of Health. Creighton and Waterbury are currently being assisted. Creighton has an identified well recharge area that the NRD has targeted for 100% cost share assistance of #1 and #2. Waterbury is utilizing the S.W.A.P. program to address contamination concerns in and around their community.

4. Information & Education Program

Public meetings to announce availability and results of programs, demonstration plots, and management efforts are being held throughout the NRD on an on-going basis. With the cooperation of Knox County Cooperative Extension and Soil Conservation Service, the Bazile Triangle WQSP has made available irrigation and fertilizer management programs with consultant supervision and federal funding. Some of the results of the project, for example, showed reduced average nitrogen application on corn by 38# per acre in Knox county (ref Jorgensen, 1993). Compared with the state average application rate of 144# per acre (Ag statistics, 1990) this would lead to significant benefits. In a survey done by Soil Science News, 1989, a survey of 158 local landowners showed the need for professional soil sampling services, and 83% knew of the practice and felt it was a major benefit. Public meetings with testimony by farmers together with television and radio coverage on successful efforts have led to a gradual adoption of "best management practices" in all areas of the NRD.

5. Rural Water Distribution Projects

Where contamination on a large scale has occurred in the District and alternative sources of supply or treatment are not available; the NRD will utilize its authority for Special Improvement Program Area to develop Rural Water Distribution Systems. This involves criteria specified on page 41. Projects take local interest and need to be successful.

6. Chemigation Permit and Inspection Program

Working together with DEQ, the NRD administers a preventative effort to protect groundwater supplies from chemicals applied through irrigation systems. Fertilizers and Pesticides injected into water applied to cropland prevented from backflow into wells by proper functioning equipment with inspection by NRD personnel.

7. Other Programs

As the district proceeds in monitoring activity and discovers contamination of groundwater quality, it reserves the right to work with other Districts on management efforts or add other programs it deems necessary or that become legally available to implement management of activity that causes such contamination.

IX. PLAN EVALUATION

By analysis of program response with other NRD's in Northeast Nebraska, the Lewis & Clark NRD has concluded that the programs currently presented are being favorably accepted socially and politically by area landowners, because of a proclaimed intent by the NRD to avoid regulatory measures if voluntary programs are being effective. The popularity of this approach has been significant and, the District believes, has been a successful preventative to increased contaminant levels.

While the scope of the problem areas are relatively limited, and the popularity of voluntary programs has been successful to promise best management practices, the directors feel that regulatory measures are not yet necessary. That alternative has been considered but determined to be expensive and initially counter productive because of farmers resistance to regulation and in the long run not any more effective.

Review of this evaluation as well as the Groundwater Plan itself will occur at 5 years intervals starting in 1996. Existing programs will be determined effective if contamination levels remain constant or decrease. Outside factors including farm programs, conservation plan compliance, economic considerations and other potential forces may all have a bearing on NRD program effectiveness. The decline in NRD population or improved cropping technology may also play a role.

If situations arise that indicate the capability of any district programs has been limited or made ineffective, the directors may chose to utilize other capabilities or resources in new approaches to obtain its goals in water quality.

TABLE X - LEWIS & CLARK NATURAL GROUNDWATER QUALITY OBJECTIVES

	PHASE I	PHASE II	PHASE II
HEADING	MONITOR & IDENTIFY PROBLEM AREAS	VOLUNTARY PREVENTIVE PROGRAMS	GROUNDWATER MANAGEMENT AREA
TRIGGER	ON-GOING	ON-GOING AND AVERAGE REACH 50% OF MCL FOR 2 CONSECUTIVE YEARS	50% OF WATER SAMPLES REACH 90% OF MCL FOR THREE YEARS
AREA	DISTRICT-WIDE, FOCUS: EXCESSIVELY DRAINED SOILS & HIGH CONCENTRATIONS OF IRRIGATION WELLS	DISTRICT-WIDE, FOCUS: TWO SQUARE MILES OF WELL WITH 50% MCL	MINIMUM OF 18 SQ MI. ESTABLISH BOUNDARIES ALONG SECTION LINES WITHIN 1 YEAR
ACTIONS	1. MONITOR IRRIGATION WELL QUALITY 2. HYDROGEOLOGIC STUDIES	1. ADDDITIONAL QUALITY MONITORING 2. PUBLIC MEETINGS 3. HYDROGEOLOGIC STUDIES 4. PREVENTIVE PROGRAMS, (SECTION VIII)	1. RESTRICT FALL FERTILIZER 2. IRRIGATION AND FERTILIZER CERTIFICATION 3. REQUIRED BEST MANAGEMENT PRACTICES 4. ANNUAL WATER AND SOIL SAMPLES 5. ANNUAL REPORTS 6. IRRIGATION REQUIREMENTS AND RESTRICTIONS

ADDITIONAL REFERENCES CITED

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2. Conservation & Survey Division, UNL, Bazile Triangle Groundwater Quality Study, by David C. Gosselin, Neb. Water Survey Paper, #68, 1991

3. Conservation & Survey Division, UNL, Bedrock Geology Map showing configuration of the Bedrock Surface in the Sioux City, Quadrangle of Nebraska 1988.

4. Conservation & Survey Division, UNL, Groundwater Atlas of Nebraska, 1986

5. Conservation & Survey Division, UNL, Groundwater Vulnerability to Contamination in Nebraska using the DRASTIC Method, 1991.

6. Conservation & Survey Division, UNL, Hydric Soils of Nebraska-staff prepared for Lewis & Clark NRD by Mark Kuzila and Sue Lackey, 1993

7. Department of Agriculture, Nebraska Agricultural Statistics, 1990/1991

8. Department of Environmental Quality, Nebraska Non-Point Source Management Program, 1991.

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11. Great Plains Agricultural Council, Agriculture and Water Quality in the Great Plains, #140, 1992.

12. Nebraska Natural Resources Commission, EPA STORET Groundwater Quality

13. Nebraska Natural Resources Commission, Registered Well Listing from Data Bank, 1992.

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21. US Department of Interior, Fish and Wildlife Service, National Wetlands Inventory Topographic Maps 1:24000, 1989

22. US Dept of Interior, Fish and Wildlife Service, Western Prairie Fringed Orchid Biological Report #36, Minnesota Department of Natural Resources, 1991

23. Wisconsin Geological and Natural History Survey, Guide to Groundwater Quality, Planning and Management by Local Governments Report #9, 1987.

24. Soil Science News, 1989

APPENDIX G POINT SOURCE INVENTORY LISTING 1992 INFORMATION

1. Wellhead Protection Areas (4) refer to Map #15

2. Feedlots (25) refer to Map #16

KNOX

1.	Nielsen, Lyle	SWSW 27-29N-R5W
2.	Fritz, Larry	NWSW 34-30N-R5W
3.	Bloom'n'Egg Farm	NE 7-30N-R3W
4.	Poppe, Arlen	SE 24-32N-R3W
5.	Kube, Loren	SWSW 29-32N-R2W
6.	Wortmann, James	SENW 11-32N-R2W
7.	Wortmann Dairy	NESE 11-32N-R2W

CEDAR

8.	Anderson, Leray	SW 32-32N-R1W
9.	Stevens Swiss Dairy	NENE 27-32N-R1W
10.	Stevens, Dan	NE 15-31N-R1W
11.	Lammers Ranch	NE 25-31N-R1W
12.	Pleasant Valley Livestock	NWNW 3-30N-R1W
13.	Arens Ranch	NW 27-29N-R1W
14.	Hans, Gerald	SSW 35-33N-R1E
15.	Hans, Mike	NENE 22-32N-R1E
16.	Pinkelman, Rick	NW 33-32N-R2E
17.	Leise, Jeff	W W 24-31N-R1E
18.	Pork Unlimited	ENW 12-30N-R1E
19.	Hansen, Dave	NESE 2-30N-R2E
20.	Heimes, David	NW 29-31N-R3E
21.	Karnes, Cleo	SE 8-30N-R3E

DIXON

22.	Erwin, Tom	NWNW 16-29N-R4E
23.	Logan Ltd Feedyard	SW 20-29N-R5E
24.	Lund, Loren	NESE 28-29N-R5E
25.	White, Merle J	SESE 5-29N-R6E

3. Hazardous Waste Sites RCRIS (7)

Bloomfield Monitor	110 N Broadway, Bloomfield NE 68718
Hesse's Inc	1211 W 2nd St, Crofton NE 68730
Hydraulic Components Inc	Hwy 84 & Kathol Road, Hartington, NE 68739
Northland Transportation Inc.	Hwy 59-&81 Magnet, NE 68749
Sexauer Co	1 blk SW 2nd Street off Hway 12, Crofton NE 68730
VanCleave George	Clark Ave, Allen NE 68710
Youse, Robert B.	109 Broadway Coleridge NE 68727
Fordyce Village of	Village Hall, Fordyce NE 68736

4. Hazardous Substance Storage (28)

Farmers Coop Ass'n, Allen NE 68710	petroleum, pesticides
Village Inn, Allen NE 68710	petroleum
Farmers Coop Elevator, Bloomfield NE 68718	petroleum, pesticides
Freeman Oil, Inc. Bloomfield NE 68718	petroleum
KK Appliance Co., Bloomfield NE 68718	petroleum
Kumm Oil Co., Bloomfield NE 68718	petroleum
Mr B's Quick Stop, Bloomfield NE 68718	petroleum
Terra Internat'l, Inc. Bloomfield NE 68718	pesticides
Coleridge Elevator Co., Coleridge NE 68727	pesticides
Coleridge Oil Co, Coleridge NE 68727	pesticides, petroleum
Hefner Oil & Feed Co., Coleridge NE 68727	petroleum
Art's Propane Service, Creighton NE 68729	petroleum
Country General/S&S, Creighton NE 68729	petroleum
Municipal Airport, Creighton NE 68729	petroleum
Farmers Union Coop Ass'n, Creighton NE 68729	petroleum
Farmers Union Coop Ass'n, Creighton NE 68729	petroleum
Osmond Coop, Inc., Creighton, NE 68729	petroleum, pesticides
Pete & Judy's Corner Ser., Crofton NE 68730	petroleum
Phil's Service, Crofton NE 68730	petroleum
Steffen Service, Crofton NE 68730	petroleum
Thompson Propane Ser. Inc. Crofton NE 68730	petroleum
Fordyce Coop Lumber & Supply, Fordyce NE 68736	pesticides
Wiebelhaus Service, Fordyce NE 68736	petroleum
Casey's General Store, Hartington NE 68739	petroleum
Country General/S&S, Hartington NE 68739	petroleum
Farmers Union Coop Gas, Hartington NE 68739	petroleum, pesticides
Ferrell Gas Inc. Hartington NE 68739	petroleum
Jerry's Service, Hartington NE 68739	petroleum
Kork & Kap, Hartington NE 68739	petroleum
*Lammers Oil Co., Hartington NE 68739	petroleum
Mid-America Dairymen, Hartington NE 68739	petroleum, acids, bases
*Sudbeck Services, Hartington NE 68739	petroleum
Terra Internat'l, Inc., Hartington NE 68739	pesticides
Dennis Elevator Inc, Magnet, NE 68749	pesticides
Tilton Oil Co, Magnet NE 68749	petroleum
Marron's Service, Newcastle, NE 68757	petroleum
Terra Internat'l, Inc. Newcastle, NE 68757	pesticides
Cook's Country Store, Ponca NE 68770	petroleum
Farmers Coop Ass'n, Ponca NE 68770	petroleum

Hazardous substance storage cont

Knerl Ford Inc. Ponca, NE 68770	petroleum
Daryl's Oil Co, St. Helena NE 68774	petroleum
Dewey's Oil Co. Wynot NE 68792	petroleum
Terra Internat'l Inc., Wynot NE 68792	pesticides
Wynot Oil Co., Wynot NE 68792	petroleum

5. Leaking Underground Storage Tanks (LUST sites)

Wynot	5th & St James Ave	gasoline
Ponca	309 Union	gasoline
Ponca	820 4th Street	gasoline
Ponca	211 East 3rd Street	gasoline
Newcastle	Howard Firestone Tires	
Hartington	202 South Broadway	gasoline
Hartingon	104 W Center	
Hartington	RR 1	waste oil
Crofton	1211 West 2nd	gasoline
Creighton	Hwy 13 & 59	gasoline
Creighton	615 Main	gasoline, kerosene & diesel
Creighton	509 Main	gasoline
Creighton	206 Main	gasoline
Creighton	East Hwy 59	diesel
Creighton	614 Main	diesel
Coleridge	1 mile North on Hiway 15	gasoline
Bloomfield	RR 1	used oil
Bloomfield		gasohol & diesel
Allen	Allen Oil Company	gasoline

6. EPA Hazardous Substance Spill Site CERCLIS

Van Cleave, George	Clark Avenue	Allen NE 68710
Village of Fordyce		Fordyce, NE 68736

7. Landfills

Arens Sanitation, Crofton NE 68730 Approved for Special Waste

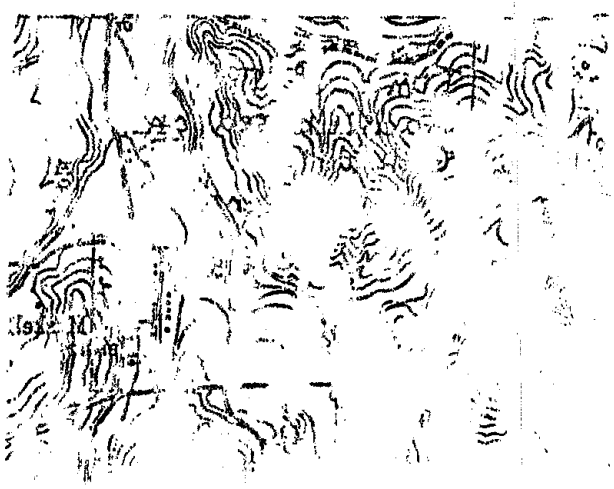
8. NPDES Permits

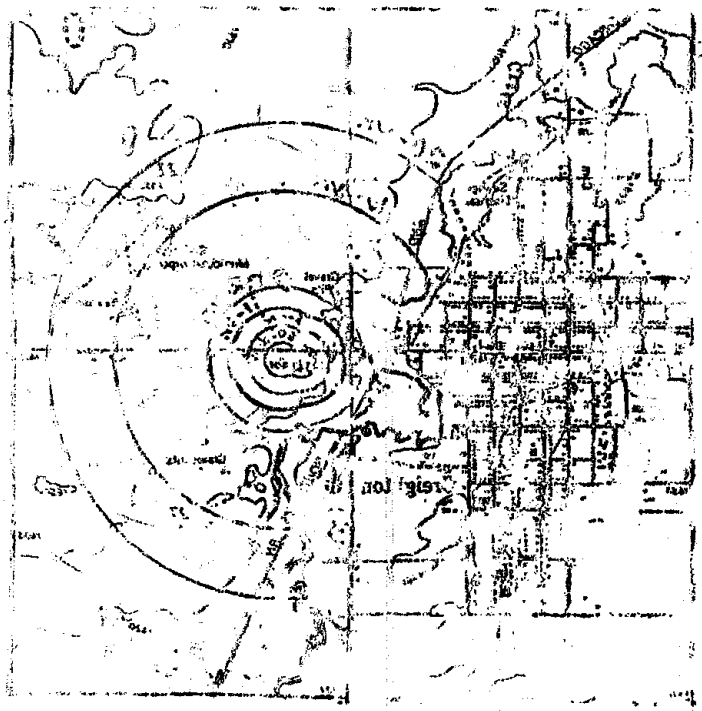
Coleridge Wastewater Treatment Facility,	Coleridge NE 68727	#25429
Fordyce	Fordyce NE 68736	#52094
Hartington	Hartington NE 68739	#49115
Lewis & Clark NRD	Hartington, NE 68739	#113832
Mid America Dairymen, Inc	Hartington NE 68739	#124397
Magnet Wastewater Treatment Facility	Magnet NE 68749	#114821
Wynot Wastewater Treatment Facility	Wynot NE 68792	#127663
Allen Wastewater Treatment Facility	Allen, NE 68710	#31241
Martinsburg Wastewater Treatment Facility	Martinsburg, NE	#113948
Newcastle Wastewater Treatment Facility	Newcastle NE, 68757	#49077
Ponca Wastewater Treatment Facility	Ponca NE 86770	#21687

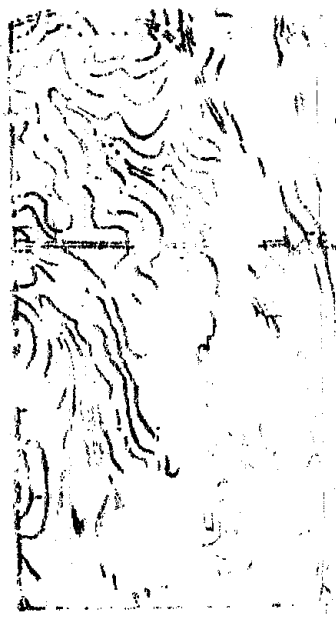
Bloomfield Livestock Auction	Bloomfield NE 68718	#113883
Center Wastewater Treatment Facility	Center NE 68724	#43265
Creighton Wastewater Treatment Facility	Creighton NE 68729	#21253
Crofton Wastewater Treatment Facility	Crofton NE 68730	#49131
SID #1, Knox Kohles Acres	Knox County	#44806
SID #2, Knox Devils Nest	Knox County	#112178

9. ASCS Grain Sites

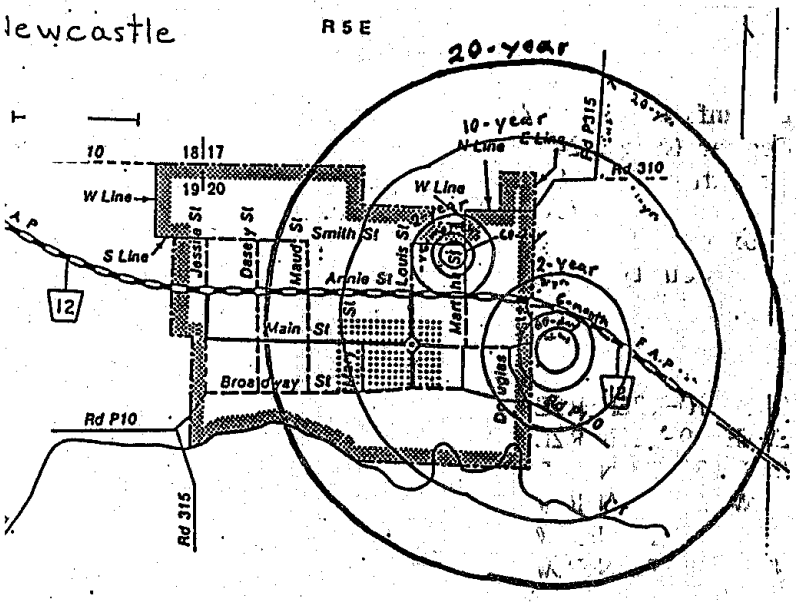
Allen,	SWSW 10-T28N-R9E
Coleridge	SWNE 9-T29N-R2E
Hartington	S SW 35-T31N-R1E
Crofton	NWNW 25-T32N-R2W
Bloomfield	Ct 3-T30N-R3W
Creighton	NENW 27-T29N-R5W





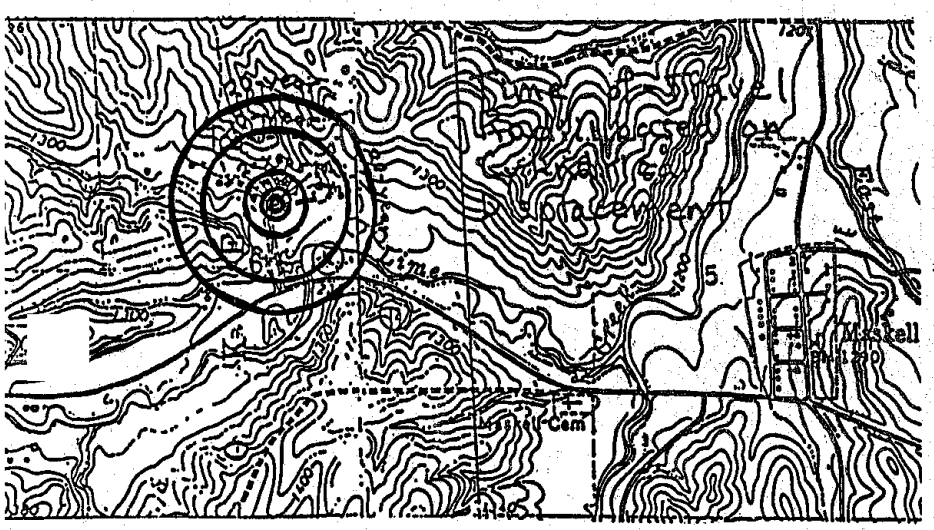


WELLHEAD PROTECTION AREA BOUNDARIES



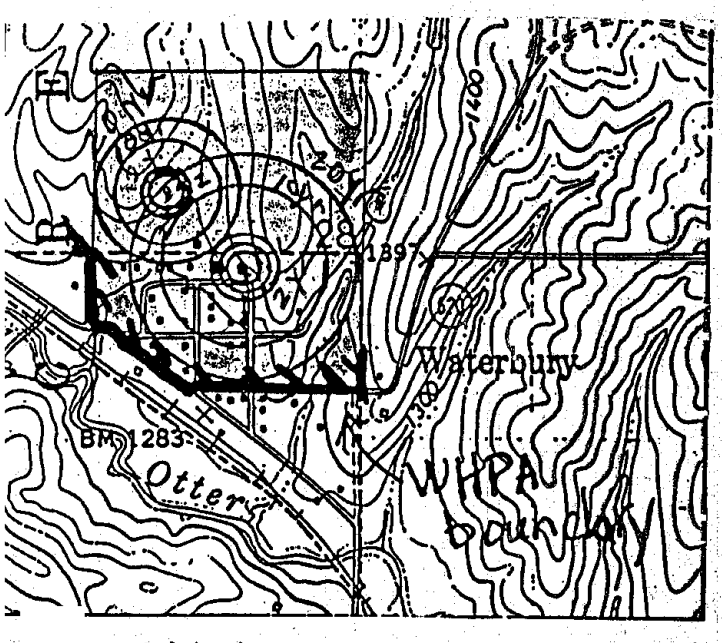
Newcastle

(Sec's 17, 20 - T31N - R5E)



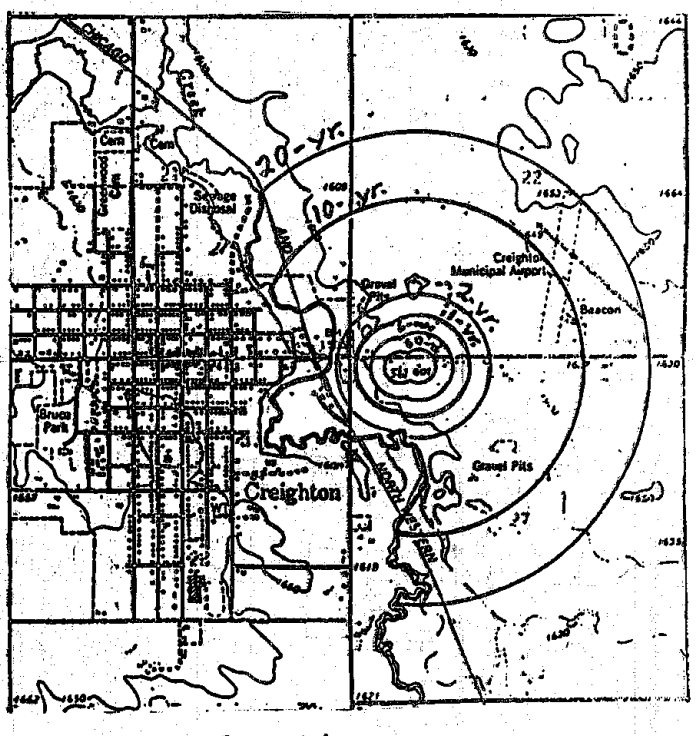
Maskell

(Sec 6 - T31N - R4E)



Waterbury

(Sec 28 - T29N - R6E)



Creighton

(Sec's 21, 22, 27, 28 - T29N - R5W)

MAP #15

MAP #16