A STUDY OF NONPOINT SOURCE GROUND WATER CONTAMINATION in the WESTERN PORTION of the UPPPER BIG BLUE NATURAL RESOURCES DISTRICT:

A Special Protection Area Report

By

Jeffrey J. Gottula
and
Martha L. Link

Department of Environmental Control
Water Quality Division
Ground Water Section
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Executive Summary

The Nebraska Department of Environmental Control (NDEC) studied the western portion of the Upper Big Blue Natural Resources District (UBBNRD) in 1991 and 1990 and the eastern portion in 1989 for possible Special Protection Area (SPA) designation. The UBBNRD requested the entire District be studied, in part due to a request for an SPA study from the City of Seward, and in part to concern over increasing concentrations of nitrate- nitrogen found in ground water in other portions of the District.

The UBBNRD encompasses one of the most intensely irrigated areas of the state, with approximately 10,900 registered wells, most of which are irrigation wells. Most of these irrigation wells derive their water from a shallow Pleistocene sand and gravel aquifer, a deep Pleistocene sand and gravel aquifer, or a combination of both. Fine-grained units of clay, silt, or till separate the two aquifers, and are present over extensive areas of the District. Perched aquifers, confined aquifers, or alluvial (stream deposited) valley aquifers also provide ground water for irrigation.

During the summer of 1991, 586 wells were sampled for water quality analyses in the western part of the UBBNRD. Regionally, some areas had higher nitrate-nitrogen levels than other areas. These areas may have geologic conditions that make detection of nonpoint source contamination more likely, such as perched aquifers or isolated aquifers which may become contaminated sooner than deep or confined aquifers.

Conditions associated with nonpoint source contamination are found throughout the UBBNRD. Intense irrigation, corn production, coarse or well- drained soils, and application of commercial fertilizers and livestock manure are common in the District. In addition, some areas of the District exhibit homogenous, elevated nitrate-nitrogen concentrations in ground water, a characteristic of nonpoint source contamination. Other areas of the UBBNRD do not have high levels of nitrate in the sampled ground water, but it is likely nonpoint source contamination is occurring there. The evidence of nonpoint source contamination is being masked by the mixing of water from different aquifer units. In the remaining areas, nonpoint source contamination is likely to occur in the foreseeable future, given the land use practices, geologic conditions, and management techniques in place.

The NDEC is recommending the designation of a Special Ground Water Quality Protection Area in the entire UBBNRD. Designation is being recommended for the entire District because of the evidence of nonpoint source contamination presented in this report, the possibility that nonpoint source contamination is being masked and not recognized, and that conditions exist for nonpoint source contamination to occur in the foreseeable future. The designation of this SPA will allow the UBBNRD to take the necessary steps to reduce and prevent further nonpoint source contamination from occurring and allow the NRD to administer a ground water quality program with the most efficiency.

Acknowledgements

The authors would never have completed a study the magnitude of this one without the help of many individuals and we want to gratefully recognize their contributions here.

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Rod DeBuhr, Russ Callan, Lori Hoemann, John Turnbull, and the entire staff of the Upper Big Blue NRD were invaluable during the sampling permission process, sampling of wells, and data gathering. Their interest, cooperation, and local expertise made the entire three-year extended study go very smoothly.

Dick Ehrman, Brad Routt, Marc Fisher, and Blake Chance assisted during well sampling. Brad Routt and Tom Trewhitt helped with map making and with report review. The following people reviewed a draft and made comments which aided us in the final copy of the report: Mary Exner Spalding, (University of Nebraska, Conservation and Survey Division), Dayle Williamsen and staff (NRC), Doug Druliner and Mike Ellis (USGS), David Aiken and Darryl Pederson (University of Nebraska), Jack Daniel and staff (NDOH), Dick Ehrman, Tom Lamberson, David Chambers (NDEC), and Rod DeBuhr (UBBNRD).

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INTRODUCTION

The Nebraska Department of Environmental Control (NDEC) conducted a study in 1991 to determine if nonpoint source contamination of ground water was occurring in the western portion (WUBB) (Figure 1) of the Upper Big Blue Natural Resources District (UBBNRD). This study completes an assessment of ground water quality for the entire UBBNRD that includes a study of the eastern portion (Figure 1) of the district (EUBB) (Gottula, 1990) and an interim report (Gottula, 1991). The assessment of nonpoint source contamination in the UBBNRD is in response to a 1989 request (Appendix A) by the district for a Special Ground Water Quality Protection Area (SPA) study.

The SPA program was created by the State of Nebraska to identify areas where nonpoint source contamination is occurring or is likely to occur, and to address that contamination. SPA studies are performed under the authority of the Nebraska Ground Water Management and Protection Act (Nev.Rev.Stat. §46- 674.02-46-674.20) and NDEC Title 196 (NDEC, 1988b). The Nebraska Ground Water Management and Protection Act and NDEC Title 196 provide that political subdivisions with evidence of nonpoint source contamination within their jurisdiction should request a study for possible SPA designation.

Nonpoint source contamination is regional in character and is associated with widespread activities such as the application of agricultural chemicals. Point source contamination, which is not regulated by the SPA program, is the result of localized discrete events or sources. Point source contamination of ground water can also result from poorly located and/or constructed water supply wells, inadequate septic systems, and leaking underground storage tanks.

Nonpoint source ground water contamination in Nebraska has been documented by studies that identified the presence of pesticides or elevated nitrate-nitrogen (NO_3-N) concentrations in ground water (Chen and Druliner, 1987; Spalding, et al., 1978; Exner and Spalding, 1979, 1991; Gormly and Spalding, 1979; Spalding and Exner, 1988; Ehrman, 1989; Link, 1989, 1990, 1991; Exner Spalding, 1990; Gottula, 1990; Tanner and Steele, 1991). The sources of contamination have been tied to land application of pesticides, fertilizers, and animal wastes.

Factors often associated with nonpoint source contamination include irrigation, permeable soils, shallow water tables, and corn production. Recent evidence of leaching of nitrates to deeper water tables has emerged (Kitchen, 1987; Gottula, 1990; Kross, et al., 1990). Kitchen (1987) documented vertical migration of nitrates beneath an upland area adjacent to the study area. Gottula (1990) documented evidence of nitrate contamination of an upland aquifer which continues into the area of the present study.

Background

In the fall of 1988, the city of Seward, citing increasing concentrations of NO_3-N in water from city wells, requested an SPA study for an area in the vicinity of the city's wellfields (Appendix B). UBBNRD at its April, 1989 meeting supported Seward's request and requested an SPA study for the entire district (Appendix A). After discussion with UBBNRD, NDEC agreed to study the district in phases.

Sampling in the portions of Butler, Seward, and Saline Counties within the district was completed in 1989. The report issued in 1990 (Gottula, 1990) cited evidence of nonpoint source nitrate contamination of the upper-most aquifer beneath the Goehner Upland. The report recommended SPA designation be delayed until study of the entire district was completed.

Timely rains during the irrigation season of 1990 prevented the sampling of an adequate

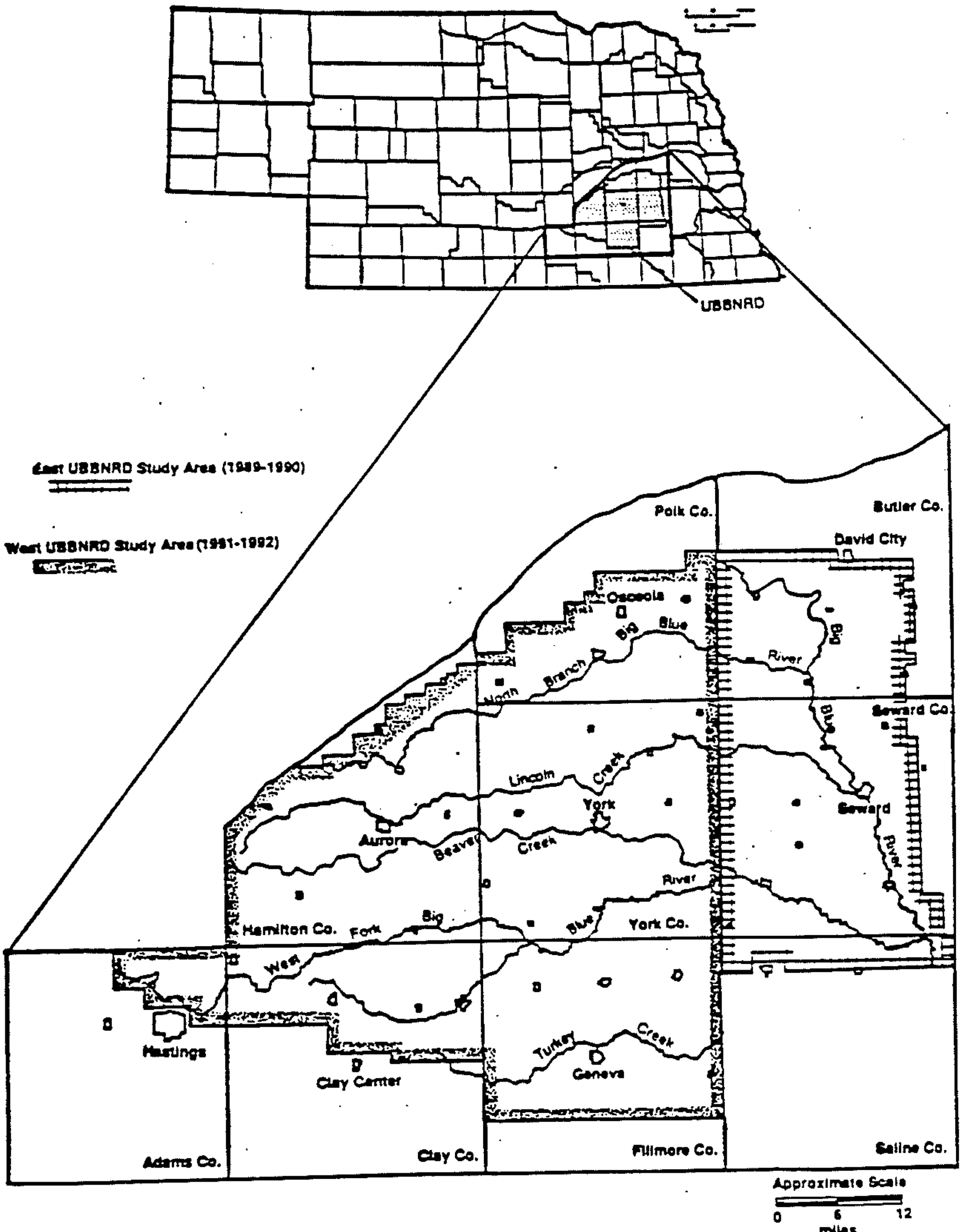


Figure 1. Location of study areas.

number of irrigation wells in York and Polk Counties. The results were summarized in an interim report issued in 1991 (Gottula, 1991). In 1991 the NDEC sampled wells in York, Polk, and the remaining counties in UBBNRD for this report.

Regional Setting

The Upper Big Blue NRD (Figure 1) is comprised of 2,840 square miles in east central Nebraska. The area studied in 1991 covered 2,145 square miles and parts or all of six counties, including all of York and parts of Polk, Fillmore, Hamilton, Clay, and Adams Counties. The climate is continental with winter temperatures often falling below 0F(-17C) and summer temperatures climbing above 100F(38C). Precipitation averages approximately 26 inches (66 cm) per year (NOAA, 1982).

The UBBNRD is drained by the Big Blue River and its tributaries including Lincoln Creek, Turkey Creek, Beaver Creek, School Creek, and the West Fork of the Big Blue River. Some areas of the District have undrained depressions in the upland regions.

Irrigation is almost entirely from ground water wells in the District. As of March, 1991, the Department of Water Resources data showed over 10,865 registered wells in the UBBNRD. The six-county area studied in 1991 contains approximately 9,500 registered irrigation, municipal, and industrial wells. Figure 2 shows the distribution of registered wells by county in the NRD.

The population of the entire UBBNRD was 55,264 during the 1990 census (Turnbull, 1991). Approximately 34% of this total was rural and 66% urban. Table 1 shows the population by county.

TABLE 1
UBBNRD 1990 Population by County

Adams	1,403
Butler	2,422
Clay	3,762
Fillmore	5,905
Hamilton	8,487
Polk	4,586
Saline	399
Seward	13,872
York	14,428
Total	55,264

PREVIOUS STUDIES

Numerous studies and projects have been undertaken in the Upper Big Blue NRD which deal with ground water and the geology of the area. The studies pertaining to the eastern UBBNRD are discussed by Gottula (1990).

The Conservation and Survey Division of the University of Nebraska- Lincoln (UNL-CSD) has published geologic logs of test holes drilled in all of the counties in the study area. These include Adams (UNL-CSD, 1953a), Clay (UNL-CSD, 1953b), Hamilton (UNL-CSD, 1960), Fillmore (UNL-CSD, 1953c), Polk (UNL-CSD, 1953d), and York (UNL-CSD, 1963). The United States Geological Survey has published several reports dealing with parts of the UBBNRD. The

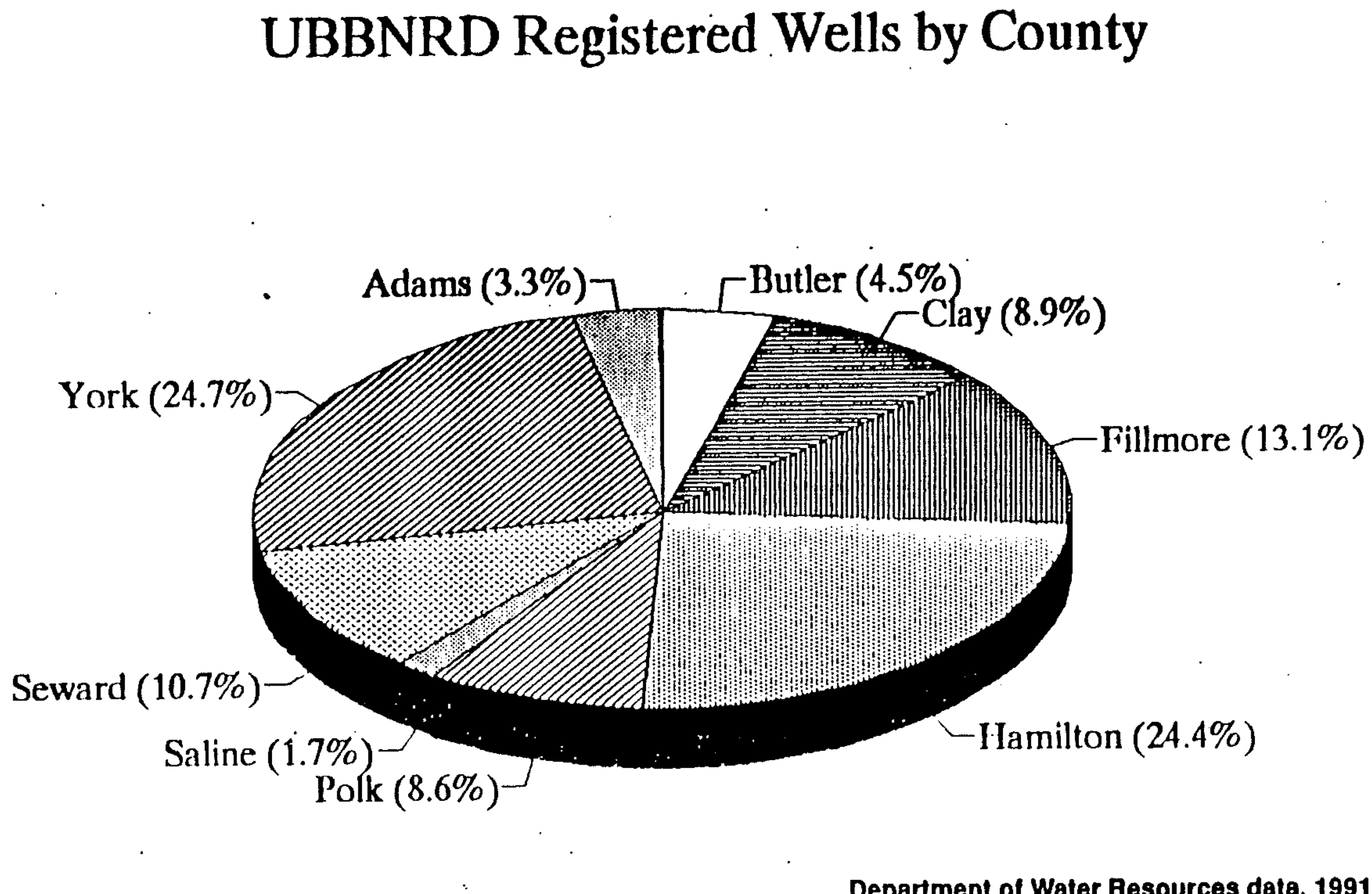


Figure 2: UBBNRD registered wells by county.

geology and ground water resources of Big Blue River basin is the subject of Water Supply Paper (WSP) 1474 (Johnson and Keech, 1959). Keech, Dreeszen, and Emery (1967) discussed the ground water availability in York County in WSP 1839-F. Hamilton County's ground water resources are covered in WSP 1539-N (Keech, 1962) and the geology and ground water resources of Fillmore County are analyzed in WSP 1839-L (Keech and Dreeszen, 1968a). Keech and Dreeszen (1968b) discussed the availability of ground water in Adams County in HA-287. Polk County's ground water is discussed by Weekly (1966) and Keech (1972). Chen and Druliner included York County in their nonpoint source High Plains Aquifer Study (1987). Because of the importance of irrigation to the area, numerical and analog models have been used to try to understand and quantify ground water supplies (Emery, 1966; Huntoon, 1973; Cady and Ginsberg, 1979; Nebraska Natural Resources Commission, 1983; Alley and Emery, 1986). Part of a masters thesis by Kitchen (1987) involved an area just south of the boundary of the UBBNRD in Clay County. The thesis dealt with nitrate-N concentrations found in the unsaturated zone soils.

SOILS

Soils are a control on the rate at which water (and the dissolved agricultural chemicals) can move toward the saturated zone. Coarse, sandy soils will transmit water more quickly than fine, clayey soils.

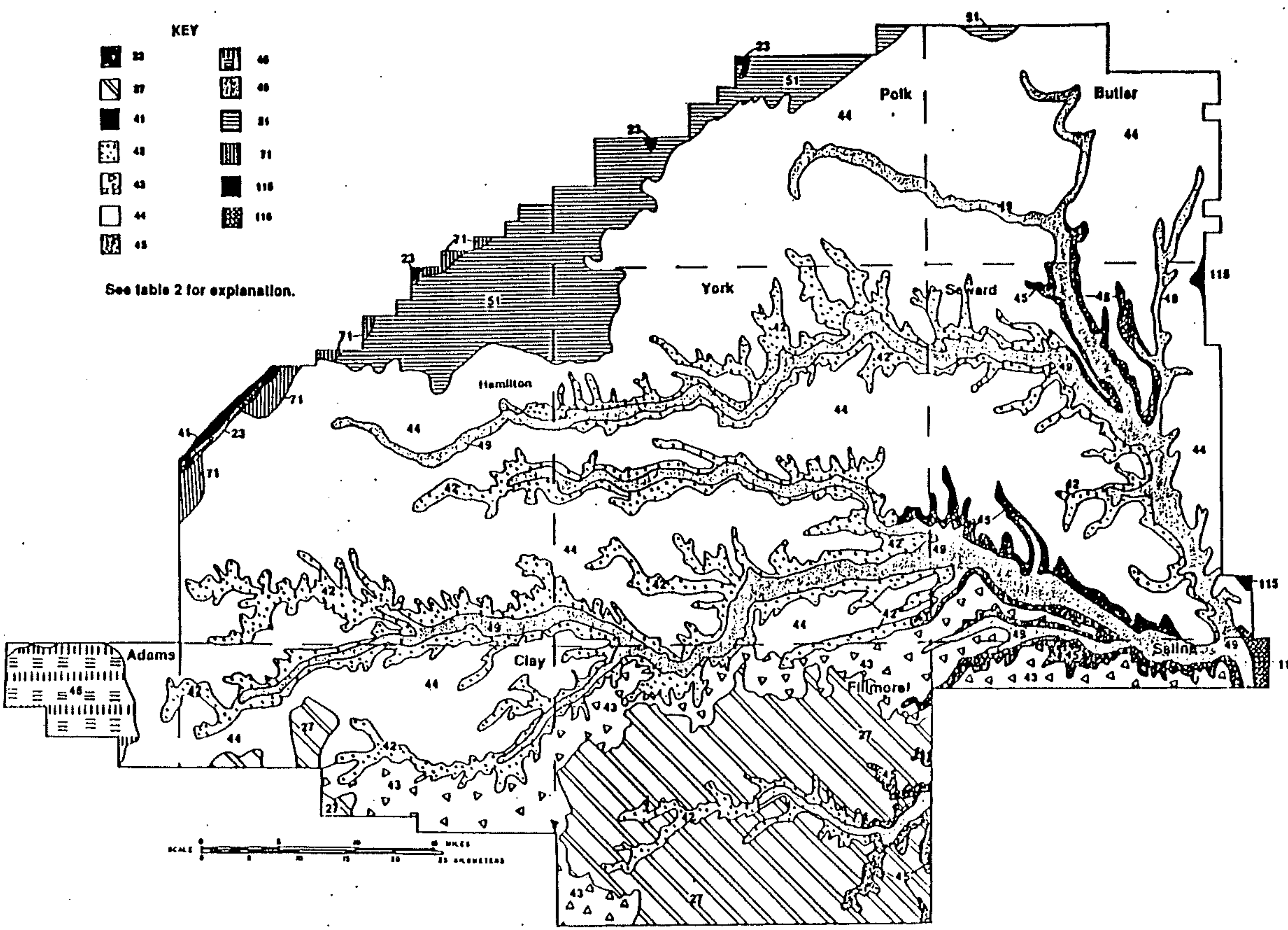
Most soils in the Upper Big Blue NRD are derived from loess sediments, a few from glacial till, and a few from alluvial, sandy eolian or river deposited sediments. Figure 3 defines the various soil associations within the district. Table 2 gives some of the physical and hydrologic characteristics of each soil association. One of the more important categories on this table is the average permeability of a 60 inch soil profile. These values range from the minimum of 0.48 inches per hour (Sharpsburg-Pawnee-Burchard association, derived from glacial till) to the maximum of 17.6 inches per hour (Gothenburg-Platte association, derived from sandy and gravelly alluvium). More detailed soils information can be found in each of the study area's county soil surveys and Dugan (1984).

LAND USE

The principal use of land in UBBNRD is irrigated row crop production. 10,865 registered wells exist in the UBBNRD, most of which are irrigation wells. Figure 4 shows the approximate location of all the registered wells in the district. In many areas, wells are so close to each other that the symbol which represents each well overlaps the next well's symbol. It is not unusual for more than six wells to be located in one section (one square mile, 640 acres) in some of the heavier irrigated areas of the district.

A map showing general land use is shown in Figure 5. This map along with the map in Figure 4 (registered wells) helps to show the intense use of irrigation on cropland in the UBBNRD.

Corn is the primary crop in the irrigated portions of the NRD. Statistics from the Nebraska Department of Agriculture (1990) show that Hamilton County had the most acres of corn harvested for grain in 1989 of any county in the state. Approximately 79% of all irrigated acres in Hamilton County were planted to corn. Irrigated corn production statistics for counties within UBBNRD are presented in Table 3.



(University of Nebraska, 1978; 1980a; 1980b; 1981)

Figure 3. Soil associations.

TABLE 2, page one
Soil Characteristics Chart
(From Conservation and Survey Div.,-UNL and USDA-SCS, 1978, 1980a, 1980b, 1981 and Dugan, 1984)

Map Code	Association Name	Position	Slope %	Parent Material	Depth	Drainage Class	Texture Surface	Texture Subsoil	Ave. perm. of 60 in. soil profile (in./hr.)	Ave. perm. of least perm. horizon (in./hr.)
23	Coly-	Uplands	9-60	Loess	Deep	Somewhat Excess. & Excess.	Silt loam	Silt loam	1.31	1.31
	Uly	Uplands	3-30	Loess	Deep	Well & Somewhat Excess.	Silt loam	Silt loam		
27	Crete-	Uplands	0-3	Loess	Deep	Mod. Well	Silt loam	Silty clay	0.58	0.22
	Hastings	Uplands	0-6	Loess	Deep	Mod. Well	Silt loam	Silty clay loam		
41	Gothenburg-	Bottomlands	0-3	Sandy & gravelly alluvium	Shallow	Poorly	Loamy sand	Sand & gravel	17.60	2.70
	Platte	Bottomlands	0-3	Sandy & gravelly alluvium	Shallow	Somewhat Poorly	Loam	Sand & gravel		
42	Hastings	Uplands	3-9	Loess	Deep	Mod. Well	Silt loam	Silty clay loam	0.81	0.40
43	Hastings-	Uplands	0-6	Loess	Deep	Mod. Well	Silt loam	Silty clay loam	0.64	0.25
	Crete-	Uplands	0-3	Loess	Deep	Mod. Well	Silt loam	Silty clay		

TABLE 2, page two

Map Code	Association Name	Position	Slope %	Parent Material	Depth	Drainage Class	Texture Surface	Texture Subsoil	Ave. perm. of 60 in. soil profile (in./hr.)	Ave. perm. of least perm. horizon (in./hr.)
44	Hastings-	Uplands	0-6	Loess	Deep	Mod. Well	Silt loam	Silty clay loam	0.81	0.36
	Fillmore	Depression	0-1	Loess	Deep	Poorly	Silt loam	Silty clay		
45	Hastings-	Uplands	0-11	Loess	Deep	Mod. Well	Silty clay loam	Silty clay loam	0.99	0.72
	Geary	Uplands	3-15	Loess	Deep	Well	Silty clay loam	Silty clay loam		
46	Hastings-	Uplands	0-6	Loess	Deep	Mod. well	Silt loam	Silty clay loam	0.99	0.73
	Holder	Uplands	3-9	Loess	Deep	Well	Silt loam	Silty clay loam		
49	Hobbs-	Bottomlands	0-2	Silty alluvium	Deep	Well	Silt loam	Silt loam	1.40	1.30
	Nord	Footslopes & terraces	0-3	Loess	Deep	Well	Silt loam	Silt loam		
51	Holder	Uplands	0-6	Loess	Deep	Well	Silt loam	Silty clay loam	1.30	1.30
71	Kenesaw-	Uplands & terraces	0-9	Loess	Deep	Well	Silt loam	Silt loam	2.03	2.03
	Hersh	Uplands	0-15	Eolian Sands & loams	Deep	Well	Fine sandy loam	Fine sandy loam		

TABLE 2, page three

Map Code	Association Name	Position	Slope %	Parent Material	Depth	Drainage Class	Texture Surface	Texture Subsoil	Ave. perm. of 60 in. soil profile (in./hr.)	Ave. perm. of least perm. horizon (in./hr.)
115	Sharpsburg-	Uplands	0-6	Loess	Deep	Mod. Well	Silty clay loam	Silty clay loam	0.48	0.33
	Pawnee-	Uplands	3-11	Glacial till	Deep	Mod. Well	Clay loam	Clay		
	Burchard	Uplands	6-15	Glacial till	Deep	Well	Clay loam	Clay loam		
118	Steinauer-	Uplands	11-45	Glacial till	Deep	Somewhat Excess.	Clay loam	Clay loam	0.61	0.31
	Pawnee-	Uplands	1-11	Glacial till	Deep	Mod. Well	Clay loam	Clay		
	Burchard	Uplands	3-15	Glacial till	Deep	Well	Clay loam	Clay loam		

Department of Water Resources data, 1991.

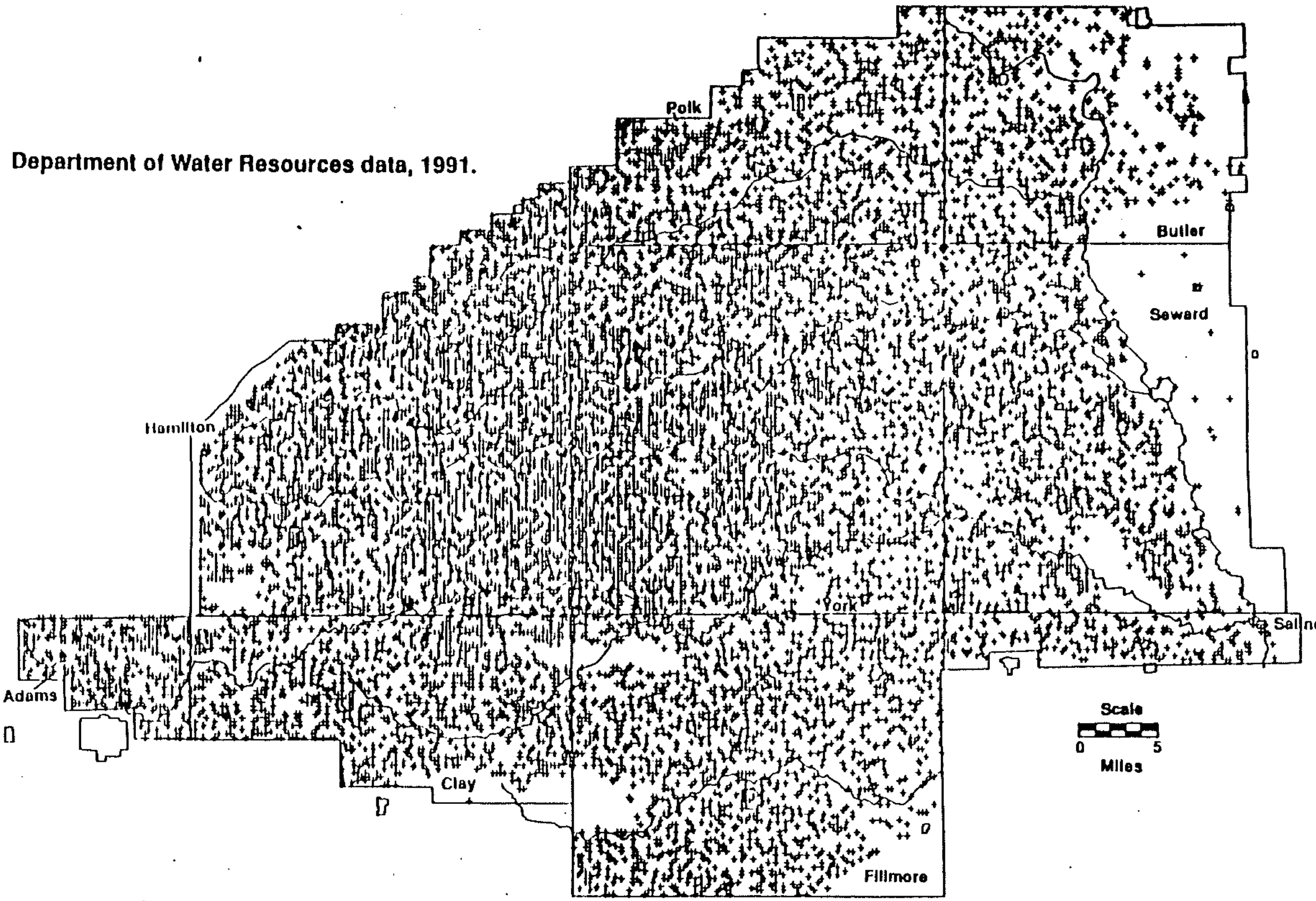
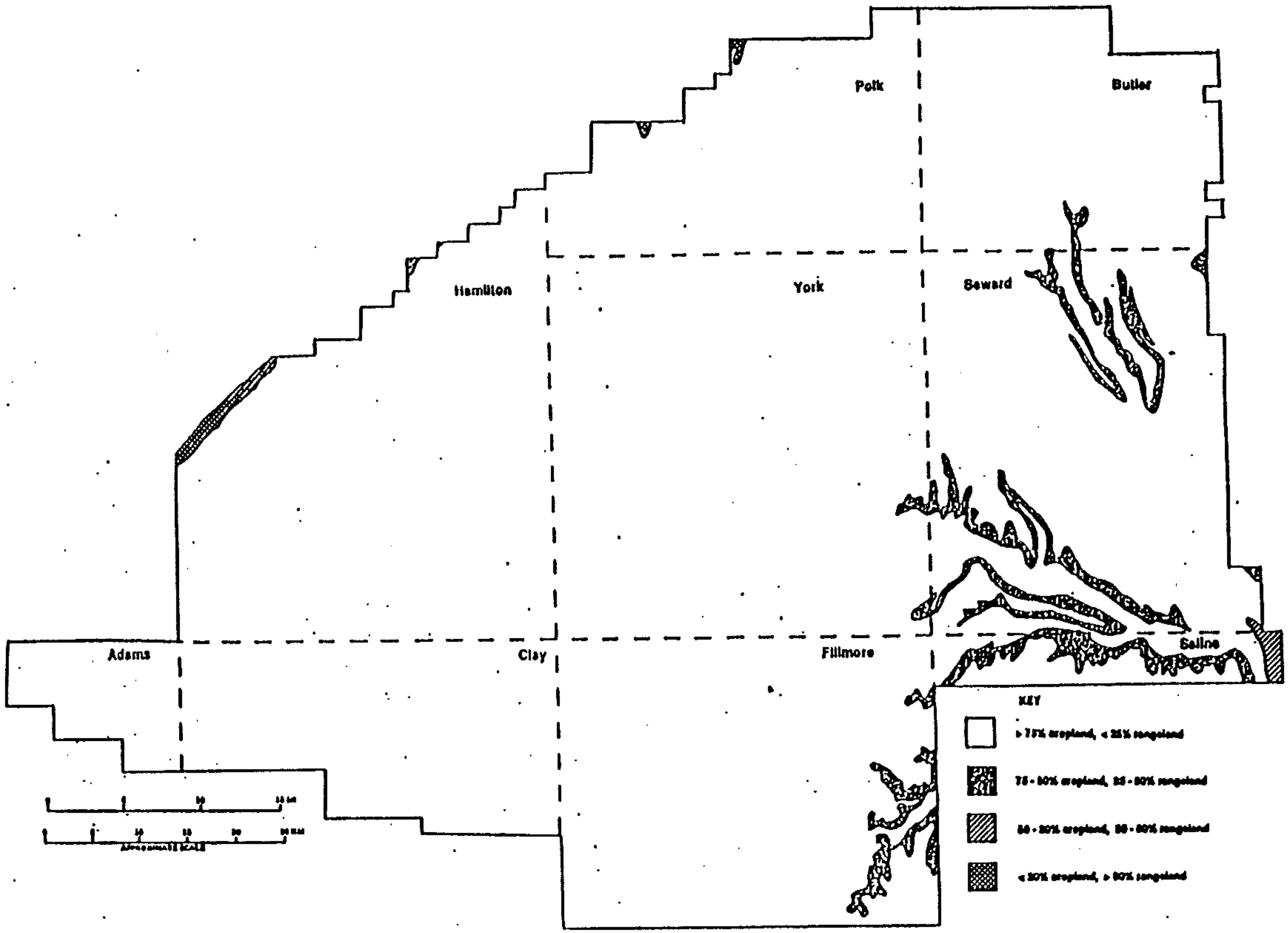


Figure 4. Location of registered wells in UBBNRD.



(Soil Conservation Service, 1984; 1985a; 1985b; 1987)

Figure 5. Land use.

TABLE 3		
Irrigated Corn Statistics (from Nebraska Department of Agriculture, 1990)		
County[1]	Percent of County which is Irrigated	Percent of Irrigated Area Planted to Corn
Adams	52%	76%
Butler	30%	69%
Clay	57%	63%
Fillmore	52%	72%
Hamilton	77%	79%
Polk	52%	68%
Saline	25%	58%
Seward	32%	62%
York[2]	66%	74%

[1] reflects entire county, not just the part in UBBNRD
[2] entire county is in UBBNRD

Irrigated corn normally requires application of nitrogen fertilizer at a rate greater than dryland corn or soybeans. Individual farm operators' fertilizer usage is not possible to quantify in this report, however general fertilizer sales on a county basis, is shown in Table 4. This table shows fertilizer sales for the 9 counties and the state as a whole for 1989 (Nebraska Department of Agriculture, 1990).

TABLE 4
Commercial Fertilizer Sales, July 1, 1988 - June 30, 1989
(from Nebraska Department of Agriculture, 1990)

			----- TONS -----
County[1]	**Anhydrous Ammonia**	**Liquid Nitrogen**	**All Types Total**
Adams	16,102	3,824	24,396
Butler	8,173	2,904	15,902
Clay	24,909	4,666	40,315
Fillmore	15,284	2,941	23,060
Hamilton	22,592	6,817	35,117
Polk	12,390	1,761	17,128
Saline	15,803	5,377	28,652
Seward	12,852	5,661	24,253
York[2]	23,925	3,558	33,051
9 County Total	**152,030**	**37,509**	**241,874**
State of Nebraska	**597,741**	**478,827**	**1,708,412**

[1] reflects entire county, not just the part in UBBNRD
[2] entire county is in UBBNRD

These nine counties comprise only 7% of the state's total area, and according to Table 4, account for 25% of the state's anhydrous ammonia sales, 8% of the state's liquid nitrogen sales, and 14% of the total sales of all types of fertilizer.

GEOLOGY

Throughout the study area unconsolidated sediments of varying thickness mantles bedrock (e.g., Figure 6). Bedrock units are Cretaceous and Tertiary in age while the unconsolidated rocks are Quaternary deposits. Tertiary bedrock is limited to an area near the western boundary of the study area. The top of the bedrock is an erosional surface consisting of paleovalley and ridges that are unrelated to the relatively flat land surface. While Pleistocene (Quaternary) sediments are the main source of water in the study area, the aquifer thickness is controlled in part by the greater relief of the bedrock surface (Johnson and Keech, 1959; Keech and Dreeszen, 1968a).

Bedrock units are generally marine or near-shore deposits except for parts of the Cretaceous-age Dakota Group and the Tertiary-age sediments. The unconsolidated mantling sediments of Tertiary age are continental deposits. Large amounts of time passed between the deposition of the marine rocks and consolidated continental deposits and between the consolidated and unconsolidated deposits. During the time gaps additional deposition and erosion occurred, sculpting new land surfaces many times. Table 5 summarizes the geologic units found in the study area and their water-bearing properties.

Cretaceous

The oldest Cretaceous bedrock unit in the study area is the Dakota Group (Figure 7). The Dakota Group underlies the entire study area. In the east it occurs at the bottom of buried paleovalleys, and is the bedrock surface under much of Seward County. Dakota Group sediments consist of interbedded sandstones and shales. The sandstones can be a source of water, but the water is highly mineralized and is generally of limited use. The quality of water decreases from east to west and with increased depth (Keech and Dreeszen, 1959; 1968b; Keech, 1962; Keech et al., 1967).

Undifferentiated Graneros Shale and younger Greenhorn Limestone overlies the Dakota Group especially on bedrock highs. The Graneros Shale consists of shale with thin interbedded calcareous layers, rare sands, and carbonaceous layers. The Graneros Shale is not generally a source of water while the Greenhorn Limestone can yield water where secondary permeability exists. Springs have been reported near Milford in Seward County emanating from Greenhorn outcrops along the Big Blue River (Keech, 1978).

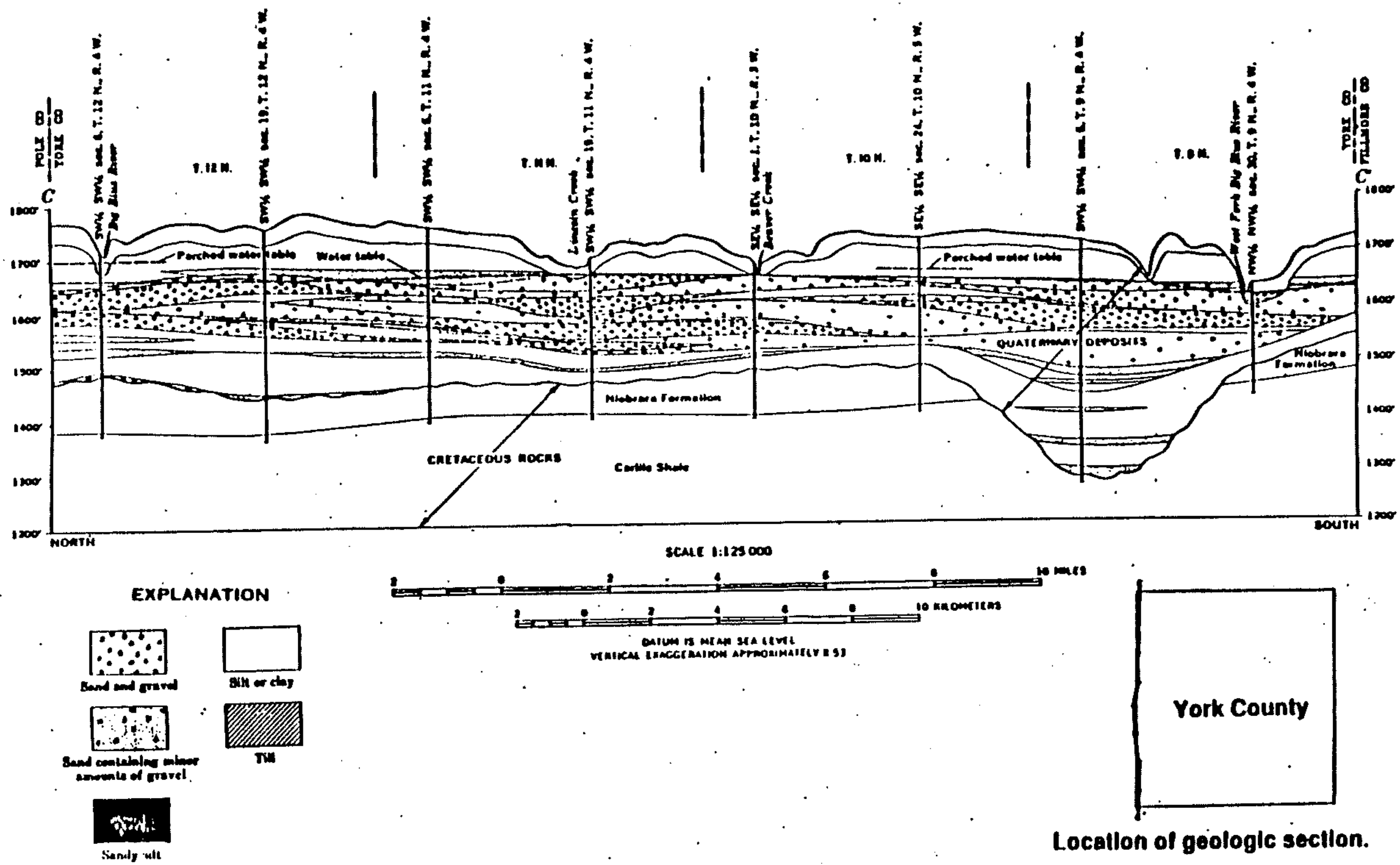
The Carlile Shale Formation occurs at the bedrock surface under much of Polk, York, and Fillmore Counties. Overlying the Graneros and Greenhorn Formations the Carlile consists of gray argillaceous shale and blue-gray shale with thin fossiliferous layers. The fine-grained Carlile is not a source of water.

The Niobrara Formation is a yellow to light to dark gray chalky shale and chalk (Keech, 1962). Occurring at the bedrock surface mainly under Hamilton, Clay, and the portion of Adams County in the study area, the formation thickens to the west. Extractable water is found in crevices and solution cavities, which occur mainly in the upper few feet of formation (Keech, 1962). The Niobrara Formation is generally not used as a source of water in the study area.

The Pierre Shale Formation overlies the Niobrara Formation in the extreme western end of the study area. The uppermost Cretaceous unit in the study area consists of marine clay shales. The unit is not a source of water.

Tertiary

The oldest Tertiary rocks in the study area are the Ogallala Group which occurs in northern



Location of geologic section.

(Keech et al., 1967)

Figure 6. York County, north-south geologic section.

TABLE 5

GEOLOGIC UNITS AND THEIR WATER-BEARING PROPERTIES
(Based on Keech et al., 1967)

System	Series	Stratigraphic Unit	Character and Distribution	Water Supply
Quaternary	Holocene	Surficial flood-plain and terrace deposits and soil	Unconsolidated stream deposited sand, gravel, silt, and clay	Transmits recharge water, may contribute water to wells.
	Pleistocene	Unconsolidated deposits (see Table 6 for divisions used in this report)	Wind-deposited silt, clay, and sand; stream-deposited sand, gravel, silt, and clay; ice-deposited till	Stream-deposited sand and gravel constitute the major reservoir in study area and yield water to large-capacity wells.
Tertiary	Pliocene	Mostly unconsolidated silt	May blanket bedrock at base and on side slopes of paleovalleys	Generally too fine textured to yield water to wells.
	Miocene	Ogallala Group	Silt, sandy silt and clayey silt containing lenses of sand and locally a basal gravel; partly cemented but principally unconsolidated	Not a known source of water supply in study area, may yield water to some domestic wells
Cretaceous	Upper Cretaceous	Pierre Shale Formation	Black, dusty gray and brownish clay shales, thin layers bentonite	Not known to supply water to wells
		Niobrara Chalk Formation	Chalky shale, and chalk	May contribute water to wells from crevices and solution cavities
		Carlile Shale Formation	Gray argillaceous shale and bluish-gray shale with thin fossiliferous limy layers.	Not known to supply water to wells
		Greenhorn and Graneros Formations Undifferentiated	Shale with thin calcareous layers, sand, sandy shale, and soft gray limestones interbedded with gray shales	Greenhorn limestone may contribute water where secondary permeability exists
	Lower Cretaceous	Dakota Group Undifferentiated	Principally composed of sandstones and shales	Sandstones may be aquifers but water may be mineralized

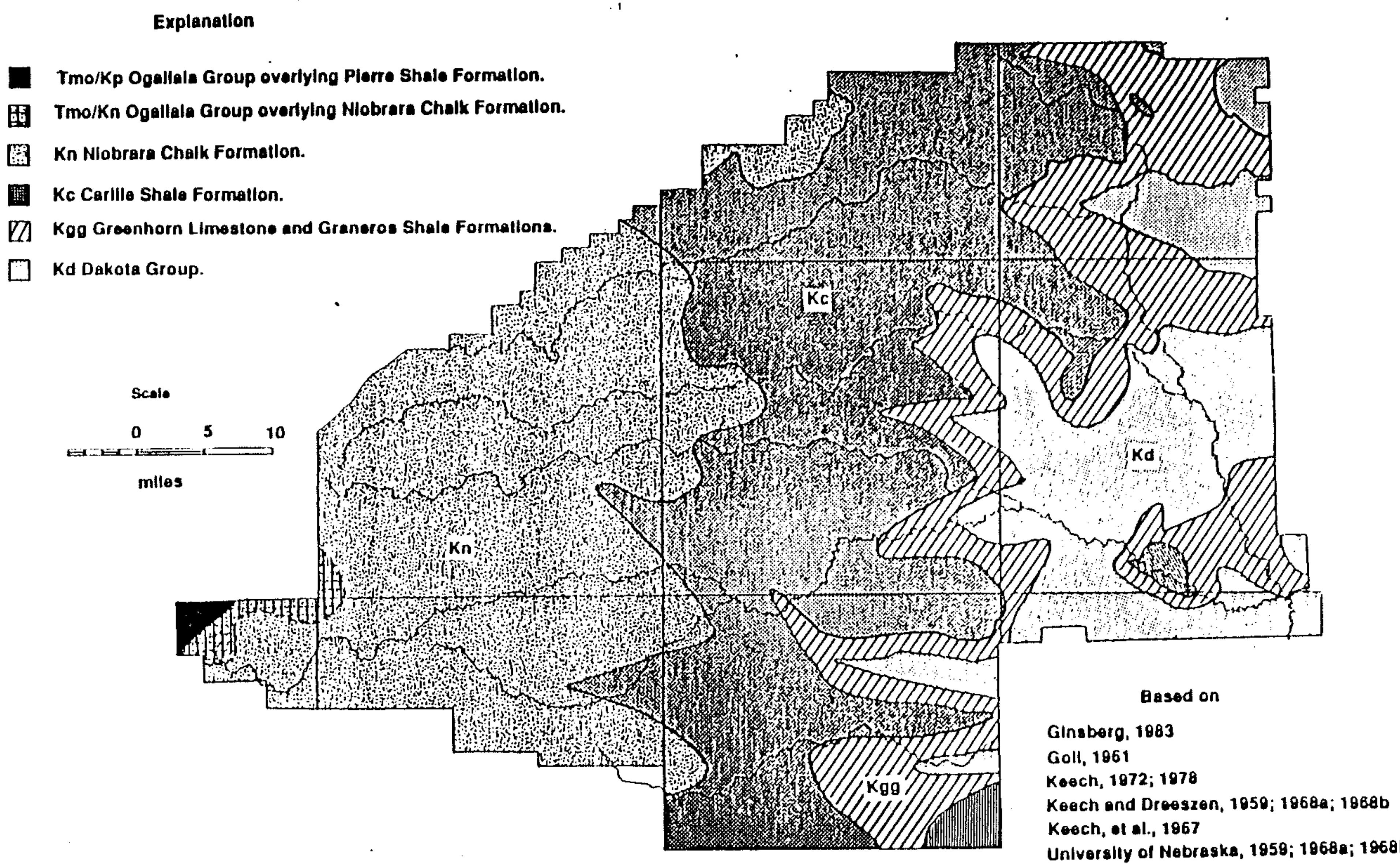


Figure 7. Distribution of bedrock units.

Adams and southwestern Hamilton Counties. Ogallala Group rocks are continental deposits lying unconformably upon marine Cretaceous units. The Ogallala completely overlies Pierre Shale in Adams County. Within the study area Ogallala sediments are composed of clays, silts, marls, small amounts of sand, and are consolidated in part. Due to the generally fine- grained nature of the sediments the Ogallala is rarely used as a source of water in the study area.

Over most of the study area fine-grained deposits of possible Pliocene age lie unconformably on bedrock and are included in the deposits labelled as Quaternary. Previously, most of the deposits were considered to be Ogallala Group sediments (Johnson and Keech, 1959). The unit is mainly unconsolidated silt with thin basal sands often present in bedrock lows. The sand present in this unit can produce low yields of water in some areas. The silt can reach significant thicknesses where it overlies bedrock lows but due to the fine- grained nature of the sediments, the unit is not a significant source of water.

Quaternary

In terms of ground water quality and quantity in the study area, the important rocks are those deposited during the Pleistocene. Pleistocene deposits underlie the entire WUBB study area. Almost all of the potable water used in the WUBB is obtained from saturated coarse-grained Pleistocene sediments. In the vadose or unsaturated zone, Pleistocene sediments act as the transporting medium and interbedded clays and silts can cause perching and lateral movement. In the saturated zone fine-grained Pleistocene sediments act as confining, or partially confining beds.

During the Pleistocene, erosional and depositional processes shaped and reshaped the landscape between periods of relative stability. The variety and juxtaposition of those deposits has resulted in complex stratigraphic and hydrologic relationships. Unfortunately the scale and detail of information available necessitate generalization of local variation although such variation may be evident in study results.

Generally sand and gravel bodies are thickest in paleovalleys, although the buried valleys can also contain considerable thickness of fine-grained sediments. Throughout the study area some coarse-grained units are areally extensive, while others are effectively or partially isolated from other coarse-grained deposits by fine-grained deposits. Relatively isolated units can be locally hydraulically connected to other units by well construction that allows commingling of waters.

For the purposes of this report the Pleistocene will be divided into three units (Table 6). The lowermost unit consists of deposits laid down during the early part of the Pleistocene, during which continental glaciers moved into the eastern portion of the study area. During deposition of the middle unit sediments, in the middle and late parts of the Pleistocene, continental glaciers did not extend into UBBNRD. Middle unit sediments consist of coarse-grained sediments from western source streams and fine- grained eolian deposits. The third and uppermost unit predominantly consists of loess that caps uplands and occurs on some older terraces and was deposited during the late Pleistocene.

The lower Pleistocene unit has the most varied depositional history of the three Pleistocene units in this discussion. The advance and retreat of continental glaciers into eastern portions of the study area created a barrier to western source streams. Coarse-grained sediments from ice-marginal and western source streams filled valleys and aggraded extensive deposits over the study area. The top of this unit in eastern portions of the study area is glacial till or associated silts and clays. These fine-grained deposits effectively separate the lower and middle units. In western and northern portions of the study area, separation of the lower and middle units is not as evident.

Under upland areas, the middle Pleistocene sands and gravels, where they occur, constitute the upper-most aquifer. Sand and gravel is interbedded with clay and silts of fluvial and eolian origin.

TABLE 6

DIVISION OF PLEISTOCENE UNITS

Position	Aquifer	Depositional Environment	Character	Water Supply Characteristics
Uppermost Pleistocene		Eolian	Loess and paleosols (silt, clay, humus)	- Transmits water - May have perched conditions
Middle Pleistocene Unit	Upper or Shallow Aquifer	Fluvial, eolian	Sand, gravel, silt, clay, humus	- First regional aquifer to be impacted by recharge and contaminants - Many domestic wells completed in this unit - Perched and water-table conditions common, semi-confined and confined possible
Lower Pleistocene Unit	Lower or Deep Aquifer	Glacial, peri-glacial, fluvial, eolian	Till, sand, gravel, silt, clay, humus	- Till and associated clays and silts act as separating unit where present - Many irrigation wells completed in this unit - Water-table, semiconfined, and confined conditions

Generally recharge water and contaminants impact ground water in these sediments first. The coarse-grained sediments are the major reservoir for significant portions of UBBNRD.

Water quality differences in the lower and middle Pleistocene sands and gravels indicate effective separation of the two aquifers. Differences in water quality were evident in wells screened in different units beneath the Goehner Upland in Seward County (Gottula, 1990). The separation of Pleistocene aquifers continues west into York County. Other areas with possible significant separation of aquifers includes north-central to northeastern Fillmore County and northern and eastern Polk County.

The upper-most Pleistocene unit caps uplands and consists mainly of wind deposited silts (loess). The capping loess is generally 20-30 feet thick and is called the Peoria Loess. Such factors as vertical cleavage, root casts and animal burrows can allow relatively rapid vertical transmission of water through the Peoria. At some locations Todd Valley sands occurring at the base of the Peoria can transmit water rapidly.

Underlying the Peoria Loess are the Gilman Canyon and Loveland Formations (Reed and Dreeszen, 1965). The Gilman Canyon consists primarily of silt, clay, and humic materials. The Loveland Formation consists mainly of silts and clays. The fine-grained nature of the Gilman Canyon and Loveland Formations can retard the rate of downward movement of water.

Quaternary age deposits fill present day valleys. The composition of floodplains and terraces are derived mainly from surrounding uplands and are generally fine-grained. Wells constructed in valley sediments generally have small yields. Water-level measurements conducted by UBBNRD and the Blue River Association of Ground Water Conservation Districts (BRAGWCD) personnel indicate shallow alluvial aquifers have good hydraulic connection to surface waters.

For more detailed descriptions of the geology of the study area, the reader is referred to Johnson and Keech (1959), Keech and Dreeszen (1959; 1968a; 1968b), Keech (1962; 1972), Weakly (1966), Keech et al. (1967), and Cady and Ginsberg (1979).

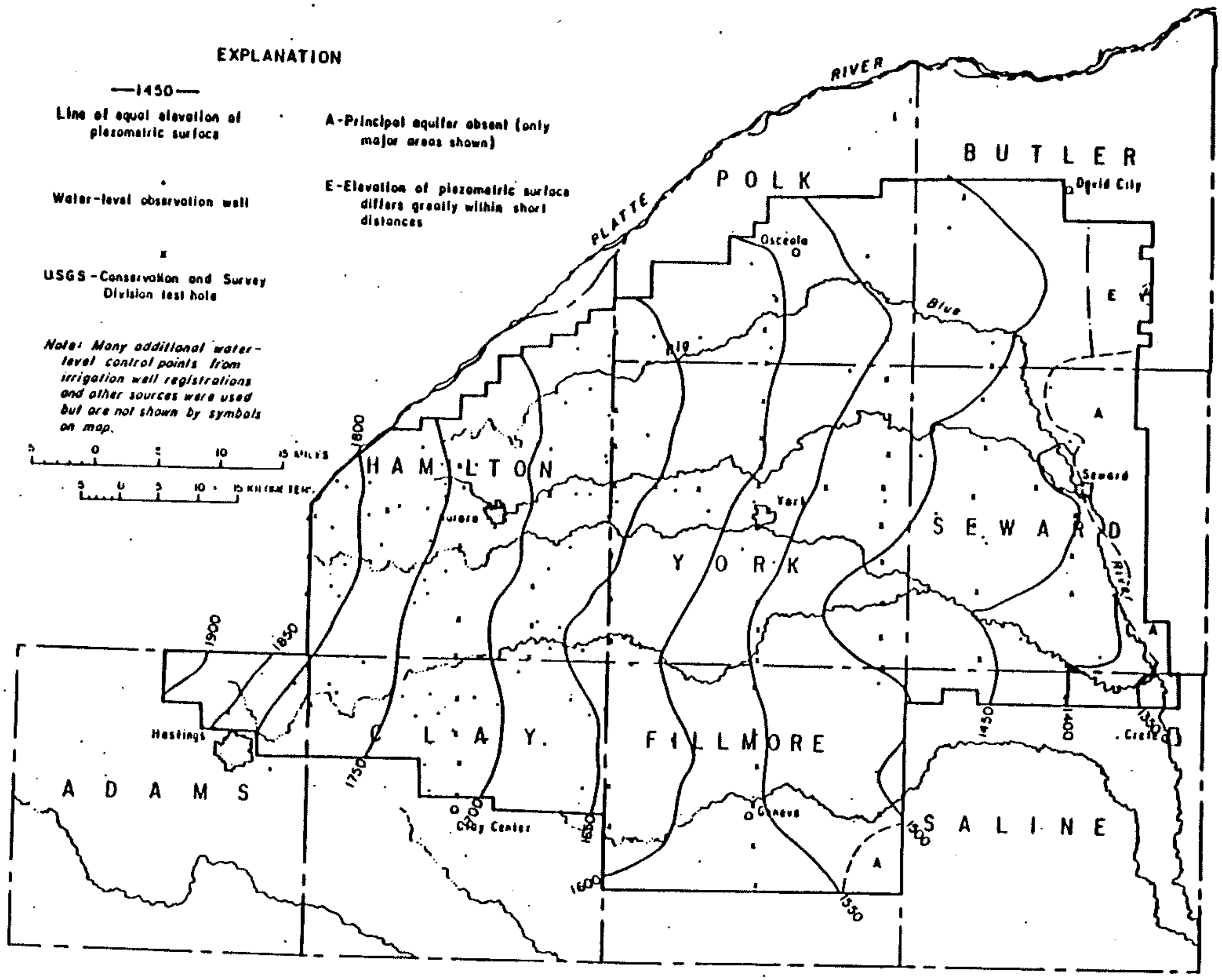
GROUND WATER

The main source of recharge to ground water in the study area is deep percolating water from precipitation and irrigation water that moves beyond root zones. Estimates of annual average recharge from precipitation range from 1.4 inches to 1.9 inches yearly with the majority near 1.5 inches yearly (Johnson and Keech, 1959; Keech and Dreeszen, 1959; 1968b; Keech, 1962; Keech et al., 1967). Research in the Central Platte Region has determined deep percolating irrigation water to be an important mechanism for transport and leaching of agricultural chemicals (Spalding, et al., 1978; Gormly and Spalding, 1979).

Additional ground water enters the study area by underflow from areas west of the study area and by the Platte River when at high stage. Ground water also flows out of the WUBB by underflow to areas east. Recharge of shallow alluvial aquifers in valleys may occur after runoff events or where surface water is present.

Any portrayal of the water table or piezometric surface is complicated by the variety of hydrologic conditions that occur in the study area. Figure 8 illustrates the configuration of the "average piezometric surface" for the entire UBBNRD in the spring of 1975. Ground water in dynamic systems constantly responds to stresses placed upon the system. Pumping wells, discharge to the surface, transpiration of plants rooted in ground water, recharging water and many other factors stress the hydrologic system, changing the water table or potentiometric surface.

Generally, the piezometric surface slopes easterly in the study area. In valleys the depth to water is shallow while on uplands, depths commonly range from 40 to 130 feet below ground



(Cady and Ginsberg, 1979)

Figure 8. Average piezometric surface, Spring 1975.

surface. Wells screened in units of different hydraulic conductivities, flow directions, or under differing confining conditions will often have different water levels.

Figure 9 shows the configuration of the base of the lowermost Pleistocene sand and gravels in UBBNRD as mapped by Cady and Ginsberg (1979). Major paleovalleys trend east-west in Fillmore, York, Polk, Hamilton, and Clay Counties. A significant paleovalley trends northwest to southeast through the central Hamilton-York county line.

Areas in the southeast portion of Fillmore County and eastern Seward and Butler counties within the UBBNRD are mapped (Figures 8, 9 and 10) as having no principal aquifer. No significant saturated coarse-grained rocks occur above high bedrock in this area. However, a few low-yielding domestic wells are found in this area. The thickness of coarse-grained rocks that are saturated with potable water is a measure of the ground water resource available. Figure 10 portrays the aquifer(s) saturated thickness by the difference between the piezometric surface (Figure 8) and the base of the Pleistocene aquifer (Figure 9).

Transmissivity is expressed as a measure of the volume of water that can be transmitted horizontally through a thickness of aquifer in a unit of time. To simplify, transmissivity is a way to portray the combination of saturated thickness of the aquifer and the ability of the deposits to readily transmit water. Transmissivities are highest where sediments are coarse-grained with many inter-connected spaces and saturated thicknesses are great. Figure 11 portrays low transmissivity in the study area. The highest transmissivities generally occur within the major paleovalleys. The lowest transmissivities are found where the aquifer(s) is thin and/or finer-grained.

Fine-grained deposits can retard water percolating downward, and cause it to be perched above the saturated zone. Perched water is widespread in northeastern Fillmore County and occurs at other locations. Where fine- grained deposits confine or partially confine aquifers, artesian conditions can occur. Artesian conditions are known to occur in and near the valley of the West Fork of the Big Blue River in Seward and eastern York Counties. Confined and semiconfined conditions are common in the lower Pleistocene aquifer. The middle Pleistocene aquifer is dominated by water table or unconfined conditions.

Some geologic settings are more likely to show evidence of diffuse contaminants. Such evidence is most likely in those aquifers that are relatively small, and uppermost aquifers where loading of contaminants initially occur. Water quality is relatively variable in these aquifers because dilution is less significant and surface impacts are greater than they are in larger, deeper aquifers.

Relatively small aquifers of low storage volume occur in the study area where the bedrock is high or fine-grained sediments isolate coarse-grained sediments. Some of those areas are evident on Figure 10 where saturated thicknesses are relatively small and on Figure 11 where transmissivities are lower. Relatively small aquifers include the Bradshaw area in west central York County; northern, southwestern and southeastern Hamilton County; and northwestern Fillmore-northeastern Clay Counties.

Uppermost aquifers in multiple aquifer settings probably include significant portions, if not most of the study area. Relatively large aquifers separated from deeper aquifers include the middle Pleistocene sand and gravels in central York County (Figure 12), and perched water in northeastern Fillmore County (Figure 13).

For more detailed descriptions of the ground water resources of the area, the reader is referred to Johnson and Keech (1959), Keech and Dreeszen (1959; 1968a; 1968b), Keech (1962; 1972), Weakly (1966), Keech et al., (1967), Cady and Ginsberg (1979).

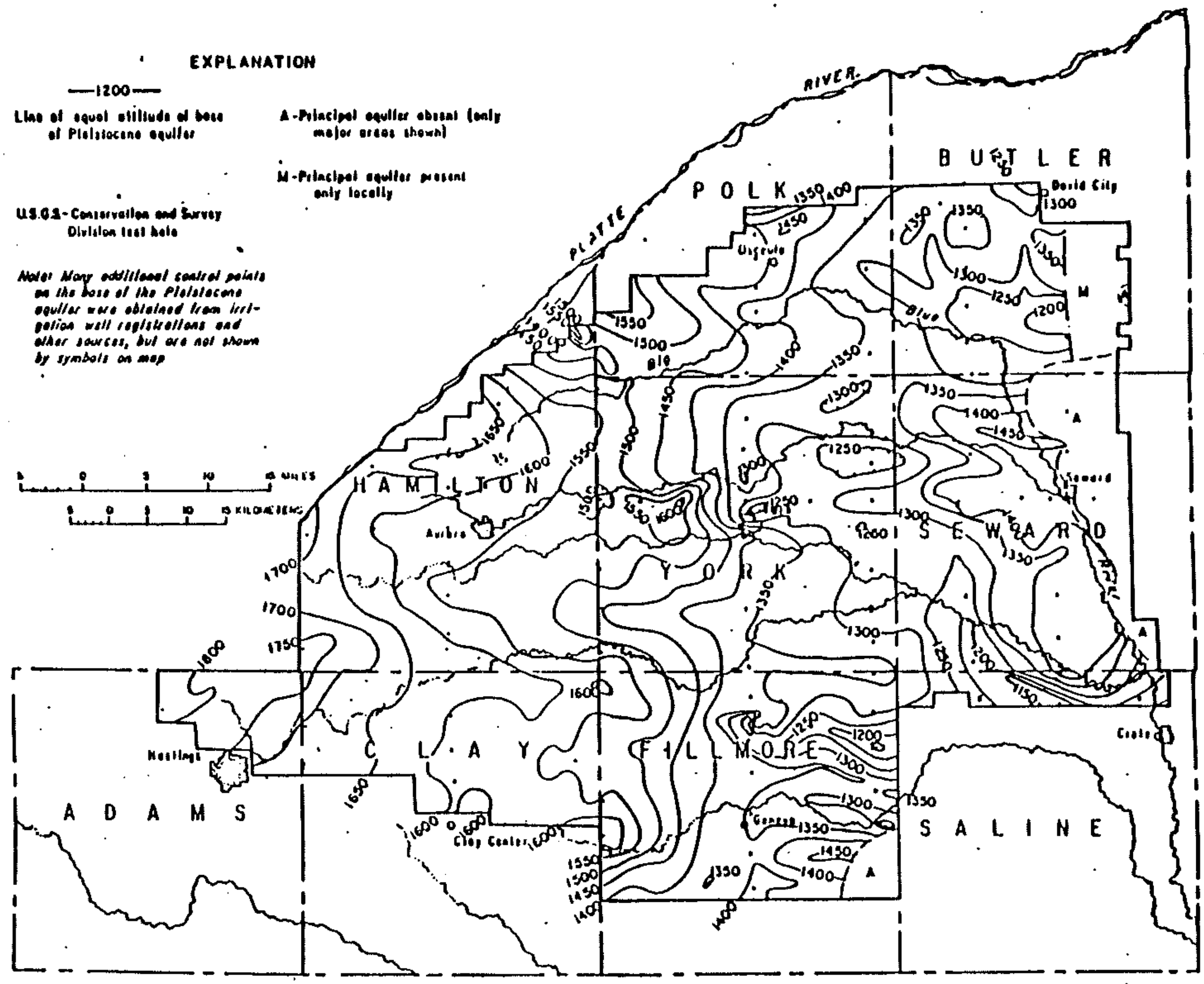
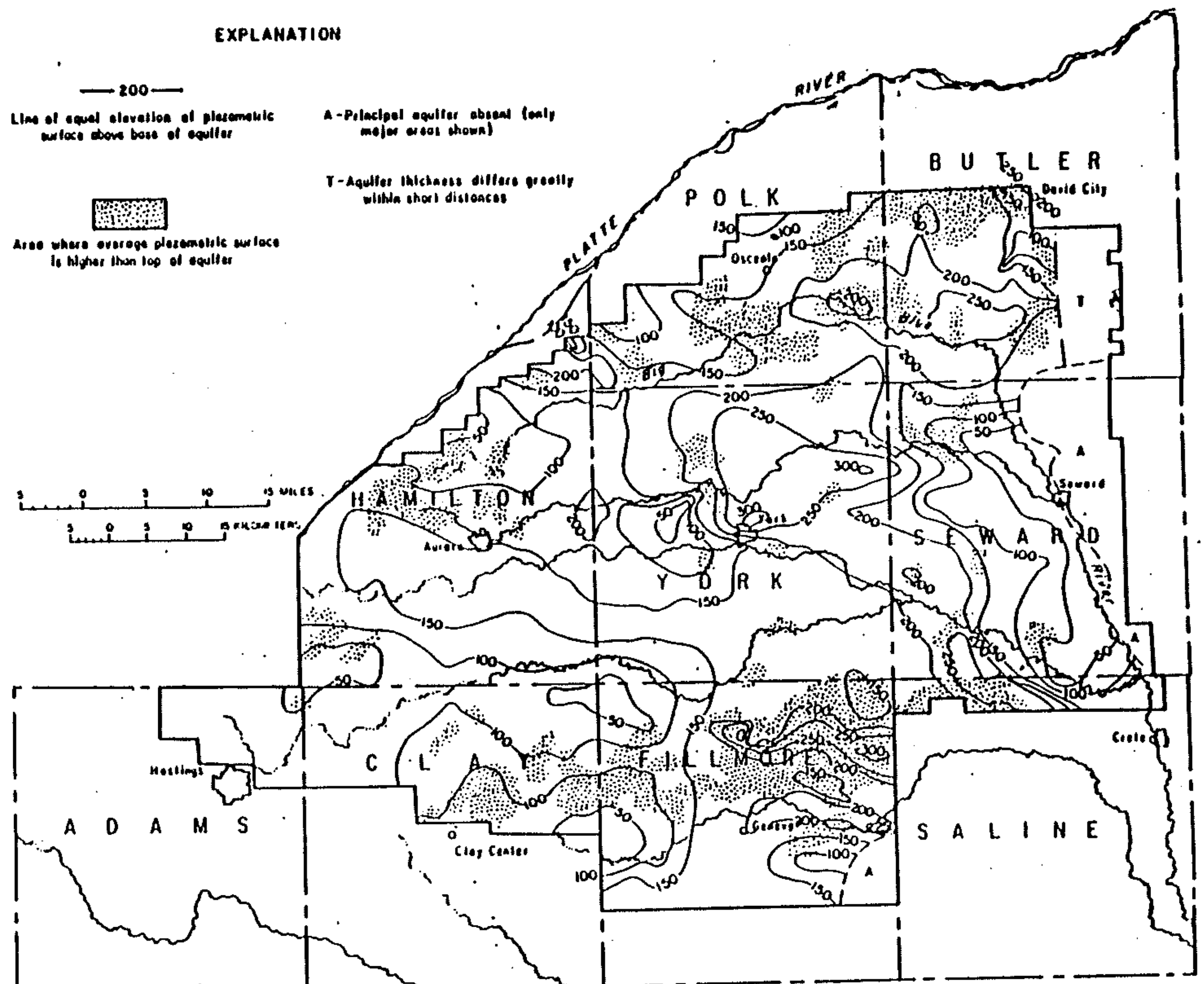


Figure 9. Base of Pleistocene aquifer.

(Cady and Ginsberg, 1979)



(Cady and Ginsberg, 1979)

Figure 10. Elevation of piezometric surface above base of Pleistocene aquifer, Spring 1975.

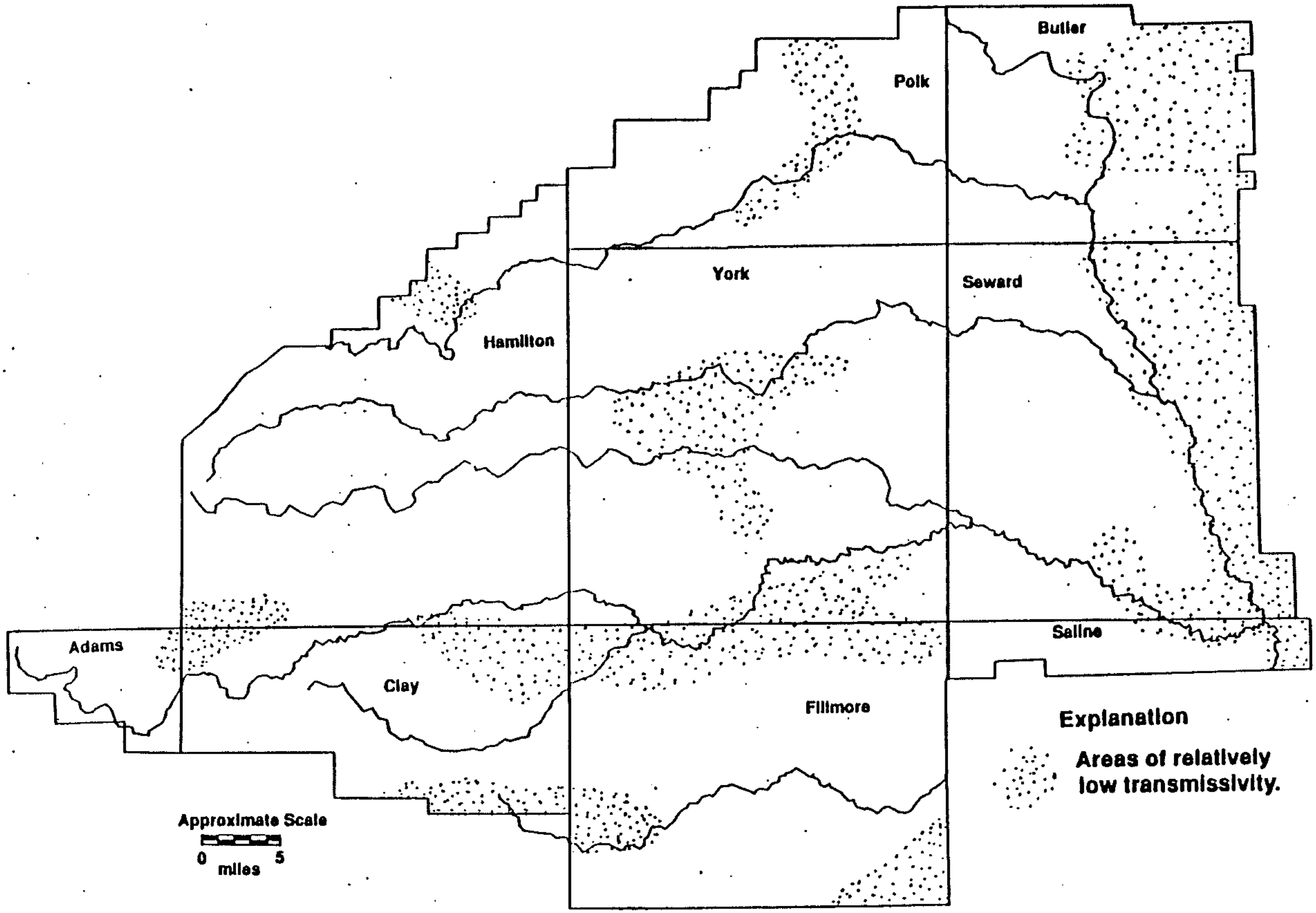
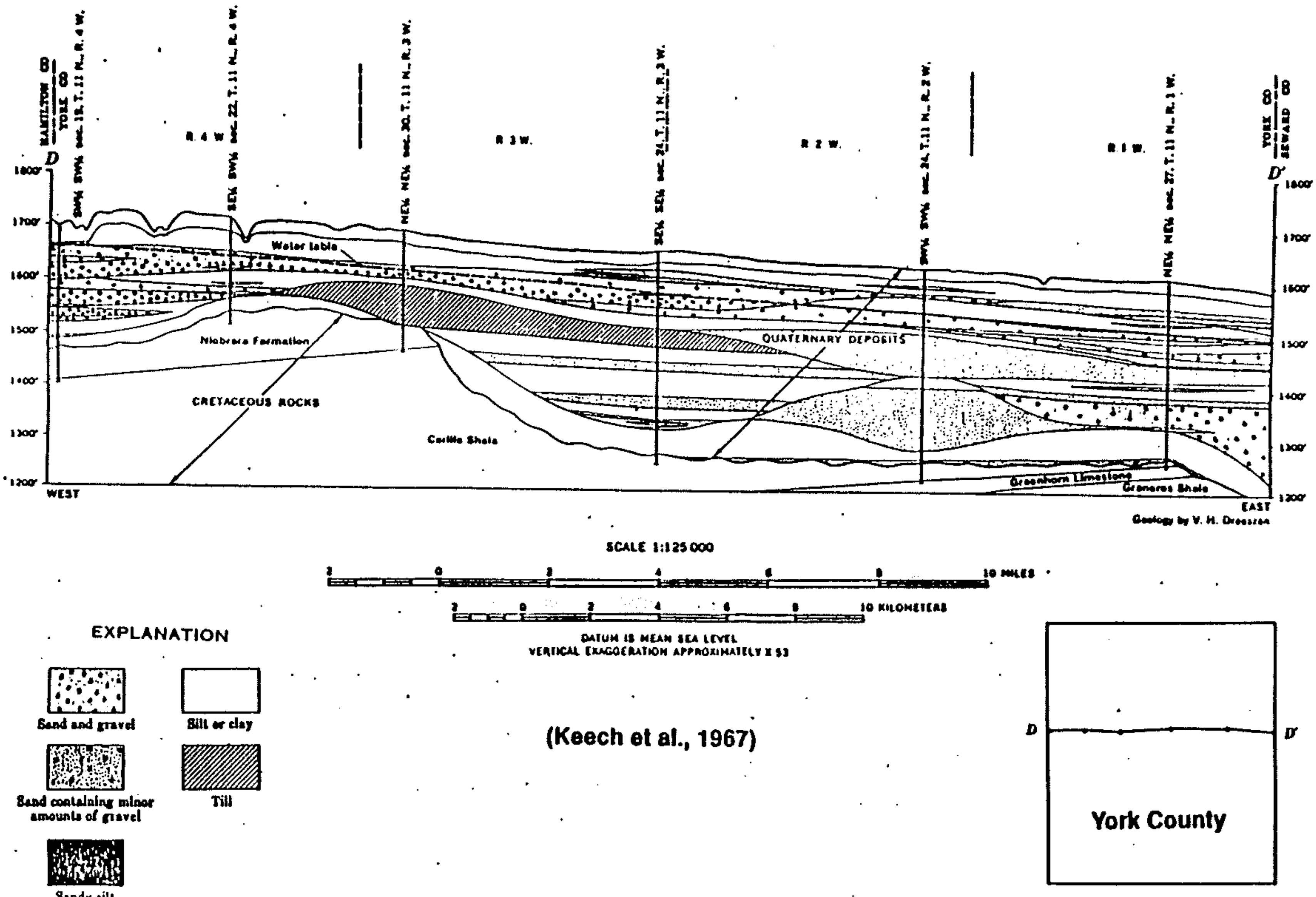
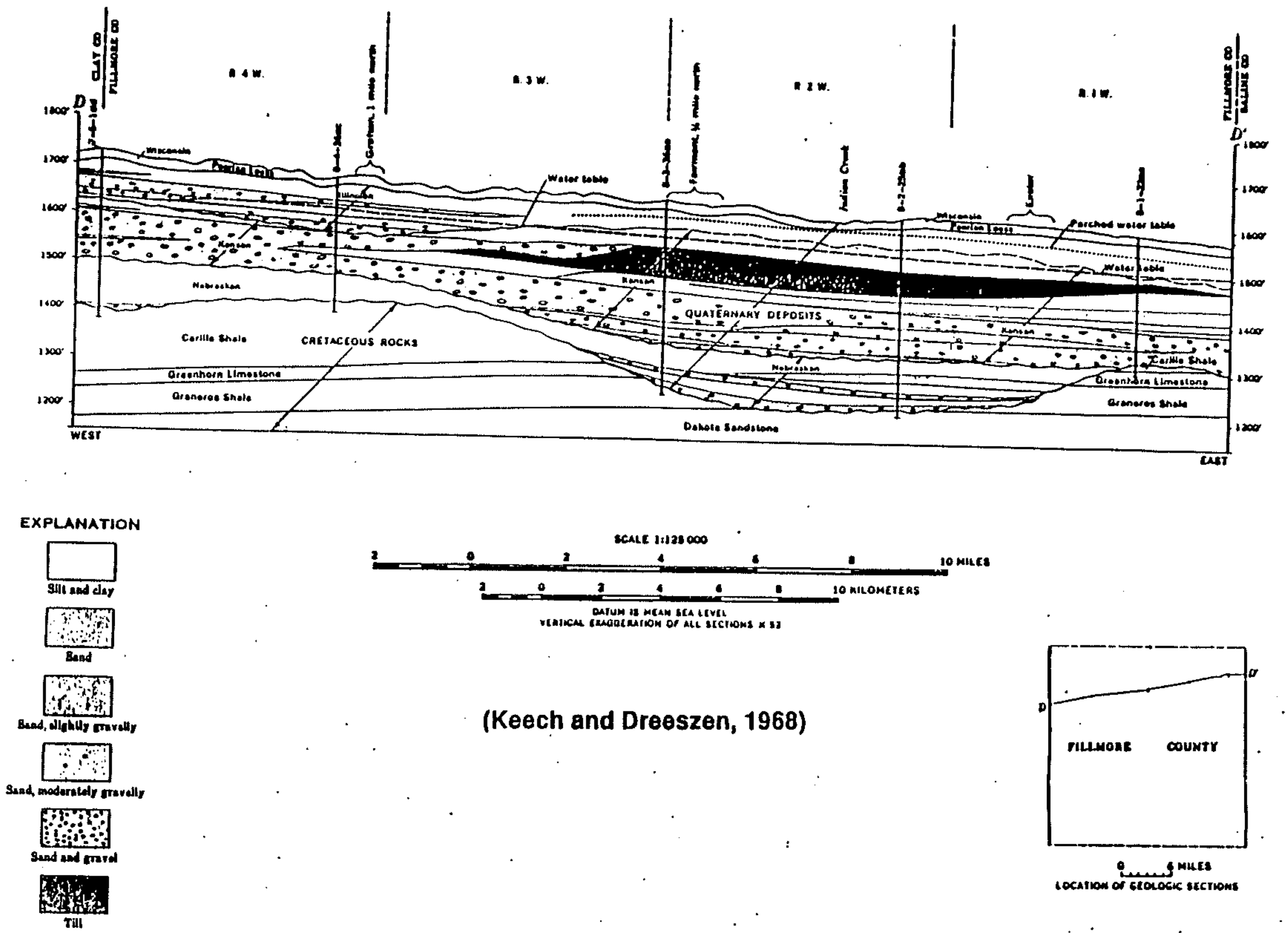


Figure 11. Areas of low transmissivity.
After Johnson and Keech, 1959.



Location of geologic section.

Figure 12. York County, west to east geologic section.



(Keech and Dreeszen, 1968)

Figure 13. Fillmore County, west to east geologic section.

PREVIOUS WATER QUALITY DATA

Long term monitoring of ground water quality in wells of known construction are helpful to assess whether nonpoint source contamination is occurring and at what rate. Monitoring of this kind has not been conducted in the study area. Limited historical information can be gathered from previous water resource investigations, public water supply testing, and relatively recent monitoring by UBBNRD and Blue River Association of Ground Water Conservation Districts (BRAGWCD).

Almost all historical sampling was done in wells constructed for delivering large quantities of water and thus often represent a blend of aquifer waters. In addition results cannot be directly compared due to different sampling protocols, analytical methodology, and quality assurance and control procedures.

Nitrate concentrations in dynamic hydrologic systems are in constant flux. Spalding (written communications, 1990) believes nitrate-nitrogen concentrations in Nebraska ground waters did not exceed 2 mg/l before human induced leaching occurred. Many historical tests of water did not include analysis for any form of nitrogen (N). The amount of nitrogen in water is often reported as nitrate ($N0_3$) or nitrate-nitrogen ($N0_3$-N). A nitrate ($N0_3$) concentration of 45 mg/l is approximately equivalent to 10 mg/l nitrate- nitrogen ($N0_3$-N).

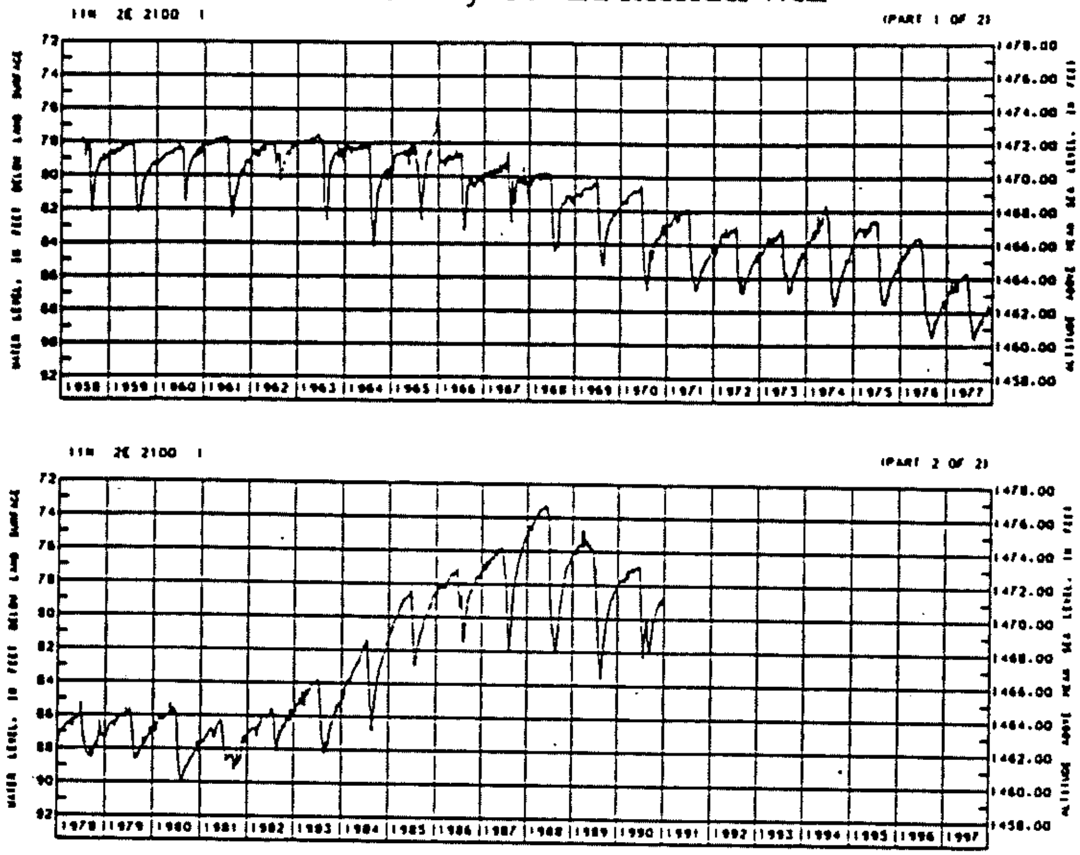
Several previous water resource investigations in the study area included water quality analyses (Johnson and Keech, 1959; Keech and Dreeszen, 1959; 1968a; Keech, 1962; 1972; Weakly, 1966; Keech et al., 1967). Most of the sampling was conducted in the early 1950s. Nitrate levels in 100 analyses in and near the study area had very low concentrations. Converted to nitrate- nitrogen only a few samples had levels as high as 6 mg/l with most concentrations below 2.2 mg/l. From this evidence it appears that nitrate- nitrogen concentrations in UBBNRD aquifers were generally below 2 mg/l before recent anthropogenic influences impacted ground water quality.

Public water suppliers are required to perform regular testing of their systems. Sampling results from public water systems often reflects the blending of several wells. The City of Bradshaw is currently under administrative order by the Nebraska Department of Health for nitrate-nitrogen levels above the 10 mg/l limit for drinking water. Near the northern boundary of the study area the City of Hordville has had nitrate levels above the maximum contaminant level (MCL) for nitrate-nitrogen in their water supply. Near the southwest border, the city of Hastings had evidence of rising nitrate-nitrogen concentrations in city water supplies during the 1980s. Within the study area, more frequent NDOH monitoring is required of small suppliers located in or near York, Aurora, and Polk. East of the study area the cities of Utica, Goehner, Rising City, and Seward all have elevated nitrate-nitrogen concentrations in system waters.

UBBNRD in cooperation with BRAGWCD has been testing ground water in the study area since the early 1980's. Most of the wells sampled are rural domestic supply wells which generally have more variable water quality. Nitrate-nitrogen concentrations were determined by use of a laboratory spectrophotometer. The average nitrate-nitrogen concentration in domestic wells sampled by UBBNRD are shown on Figure 14. Approximately 29% of the irrigation wells tested by UBBNRD have nitrate concentrations above 5 mg/1. Generally nitrate-nitrogen concentrations in samples from Fillmore, Hamilton, Seward, and York Counties have risen from the early 1980's to the late 1980's.

A well west of Seward and equipped with a continuous water-level recorder, is screened in the middle Pleistocene aquifer. Water levels in this well (Steele and Wigley, 1991, Figure 14) have trended upward from 1982 to 1987. The rise in water levels and nitrate concentrations from UBBNRD (Figure 14) sampling during the 1980s may result from increased amounts of deep perco-

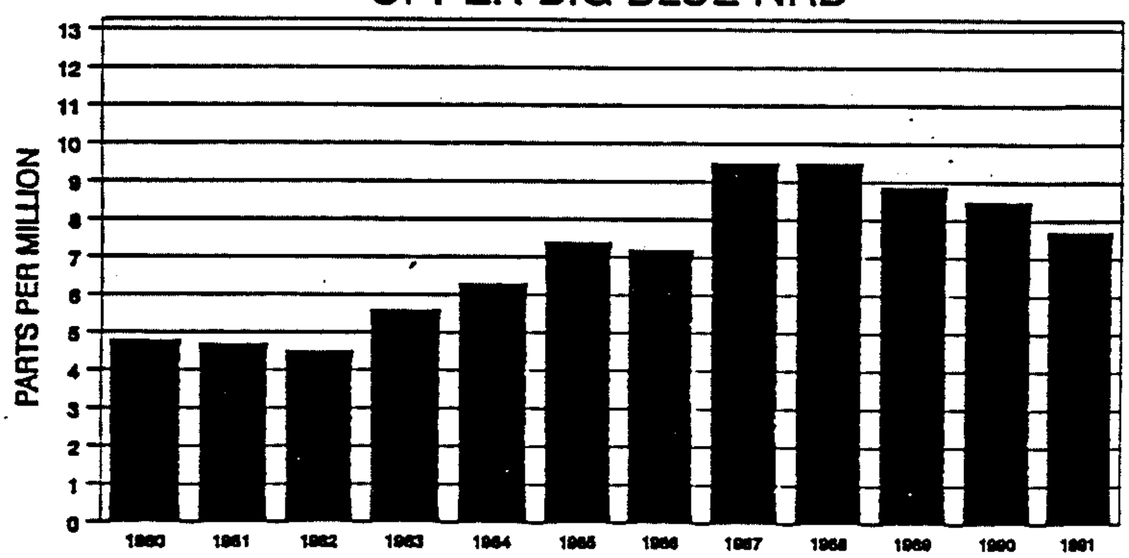
Seward County: Seward Recorder Well



(Steele and Wigley, 1991)

DOMESTIC WELL NITRATES

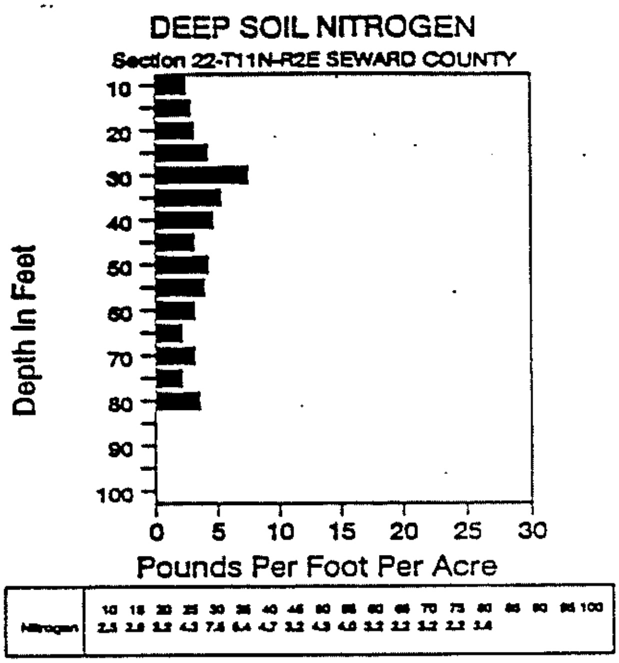
UPPER BIG BLUE NRD



NRD AVERAGE

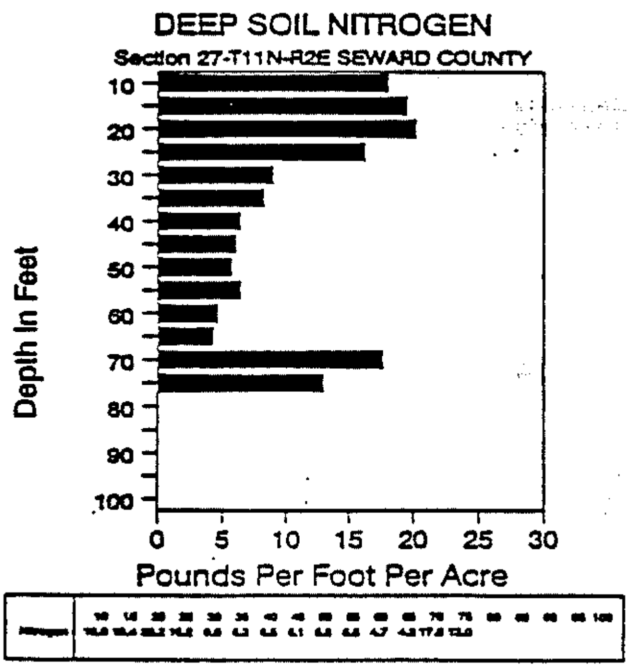
Nitrate-nitrogen data from UBBNRD.

Figure 14. Nitrate-nitrogen concentrations in domestic wells sampled by UBBNRD and water-level fluctuations in the Seward Recorder Well.



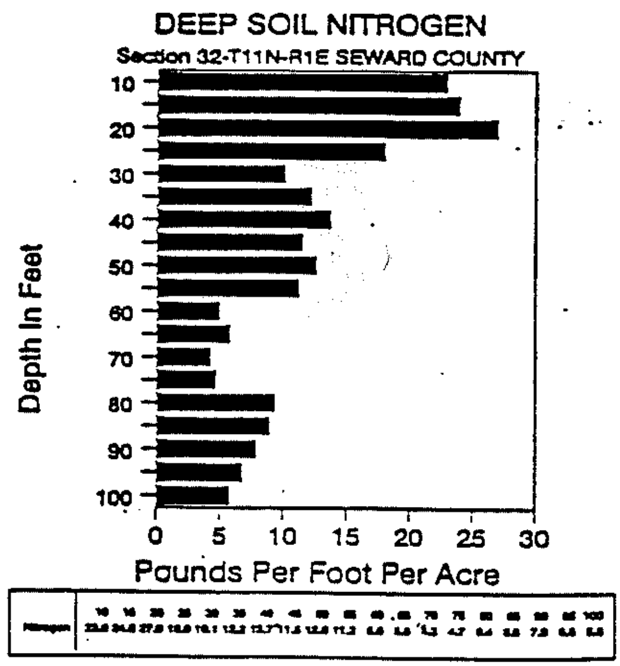
Pasture Land

Total N from 10 feet to water table - 284 lbs.



Continous Corn

Total N from 10 feet to water table = 788 lbs.

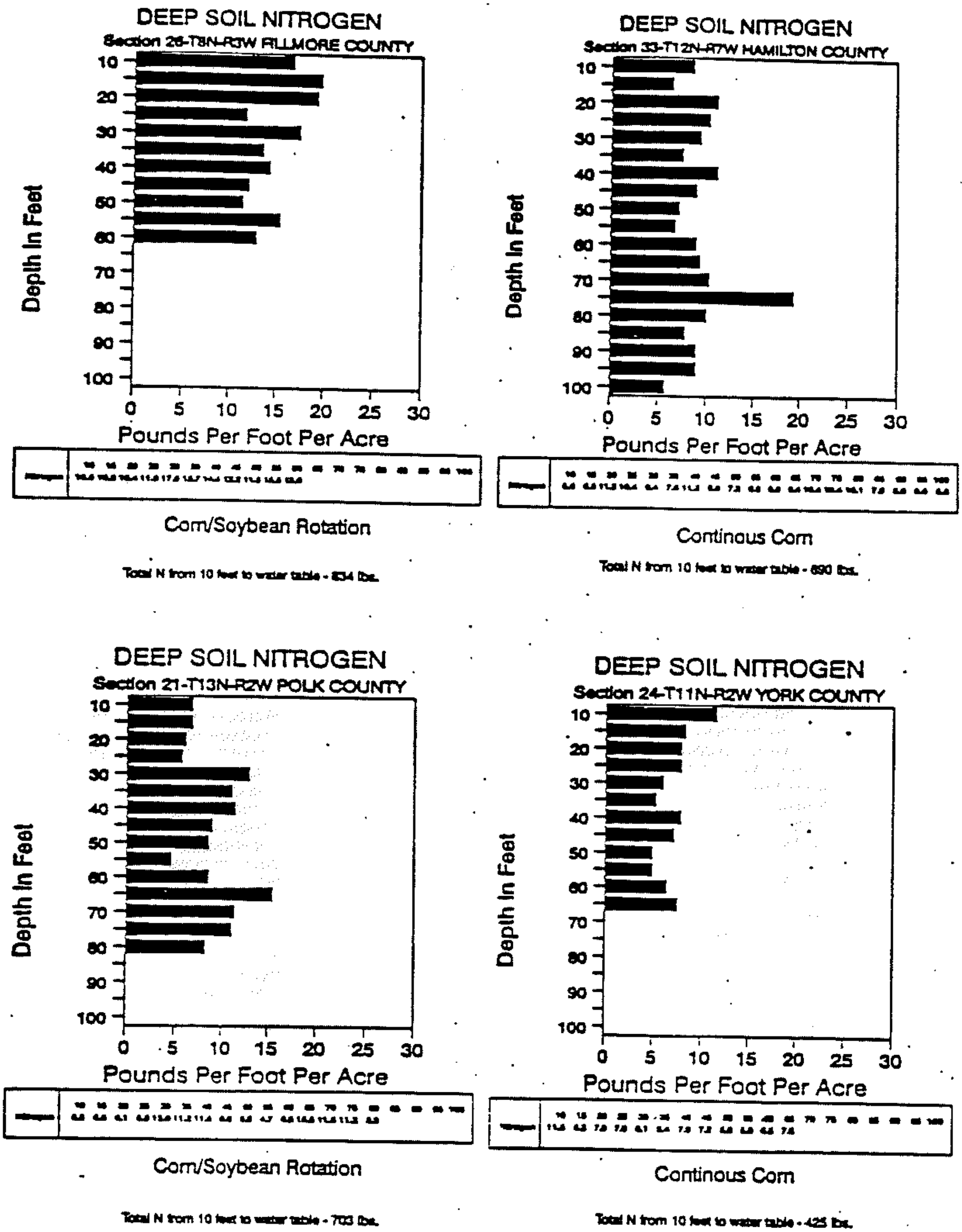


Continous Corn

Total N from 10 feet to water table - 1106 lbs.

UBBNRD data, 1990.

Figure 15. Nitrogen in sediment cores, Seward County, 1990.



UBBNRD data, 1990.

Figure 16. Nitrogen in sediment cores, UBBNRD, 1990.

lating water leaching nitrates present in the vadose zone to the aquifer. If climatic conditions influence nitrate concentrations found in the study area, nitrate levels may decline in times of drought. Lower nitrate concentrations were found during drought conditions in Iowa (Kross, et al., 1990). Declining nitrate levels may lead to perceptions that conditions are improving when relatively less deep percolating water is leaching nitrates from the vadose zone.

In 1990 UBBNRD cored unsaturated sediments underlying a pasture and irrigated cropped fields within the district. Sediment cores were analyzed for nitrogen by depth (Figures 15 and 16). Fine-grained sediments typically held relatively higher amounts of nitrogen (lithologic logs in Appendix C). Nitrogen levels were higher throughout the profile beneath cropped fields compared to the pastureland core. Relatively high nitrogen levels under cropped fields may be evidence that leaching has occurred. Nitrogen in the vadose zone can be carried downwards to aquifers by deep percolating water in the future.

SAMPLING METHODS

Wells sampled during the summer of 1991 were chosen in a random manner. At least one registered well in every other section was chosen, ownership determined, and letters sent out asking for permission to sample. Approximately 1,000 letters seeking permission to sample wells were sent out by NRD personnel, but a less than 50% positive response was returned. All other wells were sampled with the owner's and/or operator's verbal permission.

Out of the 586 wells sampled, only 24 were domestic wells. Irrigation wells are believed to reflect regional ground water quality better than domestic wells. Domestic wells may reflect contaminant loading and shallow water table conditions better than irrigation wells. Domestic wells generally have lower yields and withdraw water from a limited volume of an aquifer. The lower yield also allows domestic wells to be screened in thin, shallow, or relatively isolated aquifers. In addition, domestic wells are often located near possible point sources of contamination.which obscure regional water quality trend analyses.

The wells sampled were distributed through the six-county study area in a manner proportional to the total number of wells in each county and the study area. The 562 irrigation wells sampled of the 586 total samples represent approximately 6% of the total number of registered wells within the study area. Table 7 illustrates the weighted distribution of sampling relative to registered well distribution.

TABLE 7
Registered Wells in 1991 Study Area and Number Sampled by County

County	# of Registered Wells in UBBNRD(1)	% Total	# Sampled in 1991	% Total
Adams	388	4.0	23	3.8
Clay	1,038	10.7	65	11.1
Fillmore	1,529	15.8	97	16.6
Hamilton	2,844	29.3	175	29.9
Polk	1,007	10.4	62	10.6
York	2,884	29.8	164	28.0
TOTAL	9,690	100	586	100

(1) Nebraska Department of Water Resources data, 1991.

Actual sampling was performed according to NDEC protocol (Ehrman, 1988) during the months of June, July, and August, 1991. A site-specific field data sheet was completed on each well (see Appendix D). Information on this sheet included the physical setting and appearance of the well, crops grown nearby, and legal description. Special attention was given to factors important in evaluating the well's potential to be contaminated by a point source. Point source contamination of the well could be caused by surface water carrying agricultural chemicals draining into the casing through a cracked or undercut pad around the well. A well located at the low end of a field or near a ditch may become contaminated from surface water infiltrating into the well. Domestic wells may be located near septic systems, livestock feedlots, or agricultural chemical mixing areas. Any of these situations or conditions can directly or indirectly impact a well. If point source contamination is affecting the water quality of the well water, the data is not useful in evaluating regional water quality.

All sampled irrigation wells had been pumping more than an hour before a water sample was collected. Domestic wells were pumped approximately 15 or 20 minutes before testing of physical parameters proceeded to insure purging was complete. Prior to sampling, a tap, pipe gate, or outlet was located as close as possible to the well. The outlet was opened and allowed to run until temperature and conductivity stabilization. This procedure was followed to try to ensure the water sample would be taken from freshly pumped water and not from water which had been stagnant in a pipe or hose. Field pH, temperature, and electric conductivity were recorded.

Field conductivity was recorded using a YSI conductivity meter. Field pH was recorded using a Fisher Scientific Accumet pH meter. Field temperature was measured at the outlet with a hand-held alcohol-filled thermometer. The other measurements were taken from dedicated containers, and leftover sample water was discarded.

Samples were collected and preserved in the following manner:

One 1-liter polypropolene cubitainer was filled to the exclusion of air and left unpreserved for the analysis of major ions (bicarbonate, chloride, sulfate, sodium, magnesium, calcium, potassium, phosphate, boron, iron, and manganese). Filtering and preservation for magnesium, calcium, phosphate, iron, and manganese were performed at the laboratory upon arrival.

One 1-liter polypropolene cubitainer was filled nearly full and preserved with 5 ml concentrated sulfuric acid for nitrate-nitrogen analysis.

Recent studies have shown a correlation between high nitrate-nitrogen levels and detectable levels of atrazine (Spalding et al., 1979; Chen and Druliner, 1987; and LeMasters and Doyle, 1989). At each sampling location, a field screening test for nitrate-nitrogen was performed using a Hach nitrate- nitrogen test kit. On those samples showing a nitrate-nitrogen level of approximately 10 mg/l or higher, a Res-I-Mune triazine test kit was employed to detect the presence of triazine herbicides. Samples for laboratory pesticide analysis were collected from those wells showing positive results (i.e., containing >1.0 ppb triazine). In addition, 6 pesticide samples were taken randomly. Pesticide samples were collected in sterilized 1000 ml. clear glass jars with Teflon-lined plastic lids and were preserved on ice and refrigerated until extracted.

At least one field blank set consisting of de-ionized water and one duplicate set of samples were collected each day. These were preserved, handled, and analyzed in the same manner as the actual samples. All samples were packed on ice in coolers and transported to the laboratory by NDEC personnel. Most samples taken during the last half of the summer were taken to a private lab in Lincoln for analysis.

Both irrigation and domestic wells were sampled and analyzed for the following parameters: Nitrate-nitrite as nitrogen ($NO_3^- + NO_2^-$ as N), chloride (Cl^-), sulfate (SO_4^{-2}), bicarbonate (HCO_3^-), sodium (Na^+), magnesium (Mg^{+2}), calcium (Ca^{+2}), and potassium (K^+). The samples brought to both laboratories were analyzed using EPA approved methods.

Quality Assurance/Quality Control

Audits for quality assurance and control included elements to assess field sampling, lab analyses, and databases for accuracy and precision. Field sampling was conducted according to protocols established for SPA sampling (Ehrman, 1988). Sampling protocols included documentation of custody of each sample to the laboratories, statistical tests of field and laboratory measurements, and checks on sampling by field blanks, blind-duplicate, and split sampling. Blind-duplicates were tested for precision by performing Independent T tests. Split sampling was evaluated by utilizing sign tests and comparison.

Both laboratories performing SPA analyses have quality assurance/quality control (QA/QC) plans in place that have been reviewed by the U.S.E.P.A. An examination of a random sampling of 10% of sample analyses showed no analyses exceeded established holding times. Ionic balances were generally below 5%. Laboratory results with data outside normal ranges were reexamined for reporting errors.

Laboratory and field data was compiled in computerized data files. After data entry, all fields were examined twice for accuracy. Corrections made to the main database were checked on data subsets.

QA/QC audits found no significant problems with sampling and laboratory analytical results. Analytical results had good precision. Audits of computerized databases indicates the database correctly represents analytical results.

STUDY RESULTS

Results from laboratory analyses are tabulated in Appendix E. Table 8 presents the univariate statistical measures for each constituent in all samples. Figure 17 shows the approximate sampled locations within the WUBB and Appendix F show approximate sampled locations with well identification by county within the UBBNRD.

Most of the water sampled was of calcium bicarbonate type with a few samples of calcium sulfate type. The composition of the sampled water expressed as percentages of the total milliequivalents per liter of the major cations and anions is shown on Figure 18. The trilinear plots illustrate some of the statistical measures of the data. Among major anions, bicarbonate is dominant, and bicarbonate and sulfate are relatively variable. Outlier chloride values (6) are probably due to point source contamination. Major cations are less variable, with the dominant cation being calcium. EUBB results (Gottula, 1990) found irrigation wells to be less variable than rural domestic supply wells. Only 24 rural domestic supply wells were sampled so a comparison cannot be made.

Figure 17 shows ranges of nitrate-nitrogen concentrations at locations sampled by NDEC. A histogram (Figure 19) of the distribution of the 586 nitrate-nitrogen values illustrates the majority of concentrations to be below 5 mg/l. Seventy-five percent of nitrate-nitrogen concentrations are below 7.3 mg/l. Approximately 10% of nitrate-nitrogen concentrations are above 10 mg/l. 15 samples had nitrate-nitrogen concentrations above 15 mg/l. A majority of the samples with nitrate-nitrogen concentrations greater than 15 mg/l had possible influences by point sources as indicated by cracked well pads, high chloride and sulfate levels, and locations that allow surface water to be near the well.

Correlations between nitrate-nitrogen levels and chloride (Figure 20) and sulfate (Figure 21) are used to evaluate the sampling results for possible interference from point source contamination. As the plots show, there is very little correlation between nitrate and chloride and between nitrate and sulfate. The lack of correlations between nitrate-nitrogen and chloride and sulfate, generally

TABLE 8
Univariate Statistics for Western Upper Big Blue SPA Study

	Temperature °C	pH S.U.	Conductivity umho/cm	TNO_3-N mg/l	Cl mg/l	SO_4 mg/l	HCO_3 mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l
Number of Samples	582	478	580	584	582	585	582	582	585	585	585
Number of Samples with Data Missing	3	107	5	1	3	0	3	3	0	0	0
Number Below Detection Limits	0	0	0	0	0	0	0	0	0	0	0
Mean	12.131	7.109	502.403	5.237	15.516	69.415	279.633	30.340	13.905	87.206	6.792
Variance	1.481	0.034	15199.360	16.247	92.710	5575.035	2847.495	404.581	17.293	555.015	12.154
Standard Deviation	1.217	0.184	123.286	4.031	9.629	74.666	53.362	20.114	4.158	23.559	3.486
Coef. Variance	10.030	2.584	24.539	76.974	62.056	107.564	19.083	66.296	29.906	27.015	51.330
Skewness	5.466	0.303	1.598	1.434	6.040	6.100	0.855	15.436	2.990	1.792	17.029
Kurtosis	81.222	3.565	7.716	6.440	59.714	68.254	6.692	315.078	22.625	9.160	363.909
Minimum	10.0	6.5	2.60	0.020	2.30	2.910	97.60	1.0	0.10	38.300	3.6
25 percentile	11.0	7.0	420	2.310	10.50	31.00	239.10	23.0	11.5	71.925	5.8
Median	12.0	7.1	480	4.505	14.00	45.100	275.70	27.3	13.2	83.300	6.4
75 percentile	13.0	7.2	560	7.27	18.20	80.450	312.30	33.0	15.1	97.10	7.4
Maximum	30.0	7.7	1250	26.23	116.0	1090.00	651.50	446.0	53.1	232.30	81.6

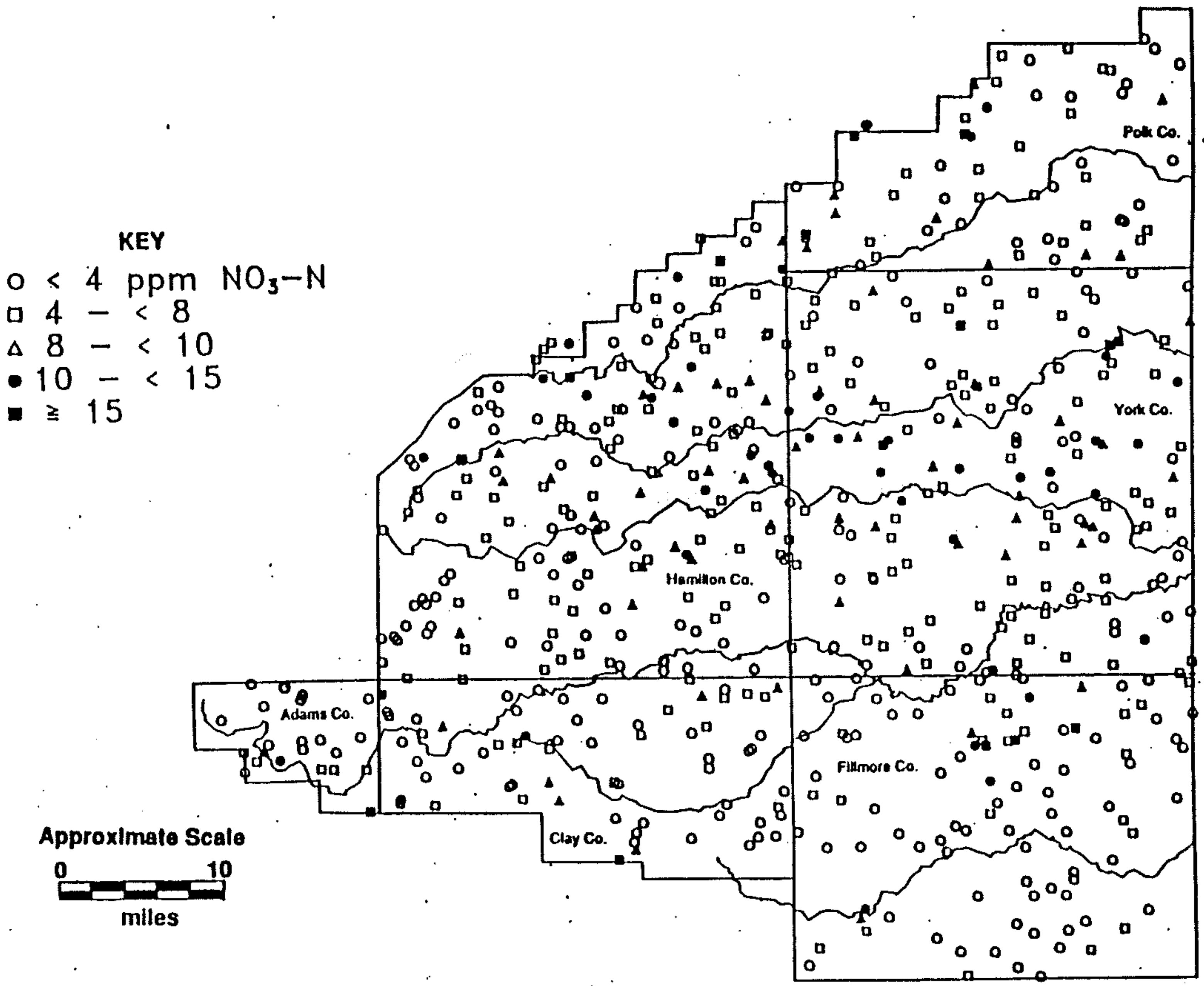
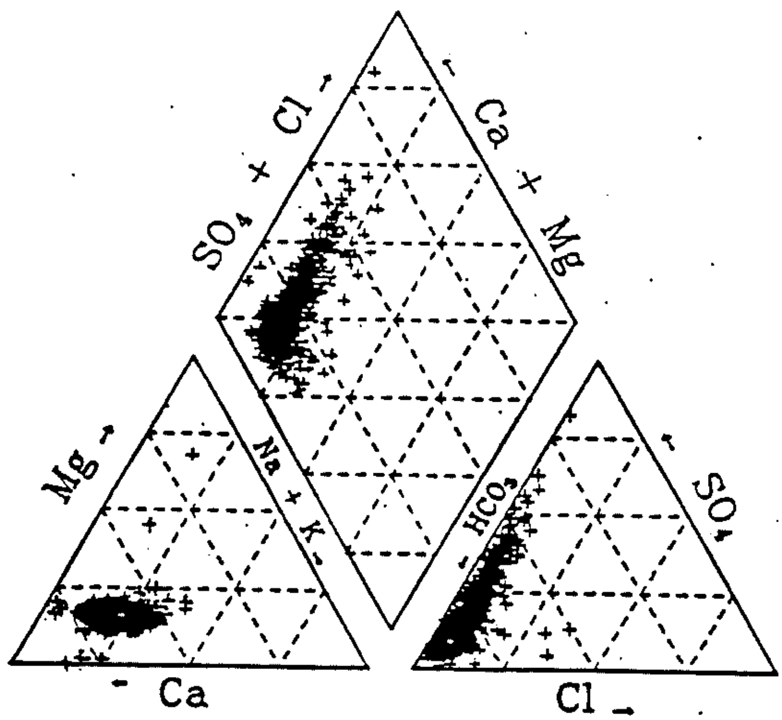


Figure 17. Generalized nitrate-nitrogen concentrations in wells sampled by NDEC, WUBB SPA Study, 1991.



Percent of total milliequivalents per liter.

Figure 18. Percent ionic composition of WUBB SPA sampling, 1991.

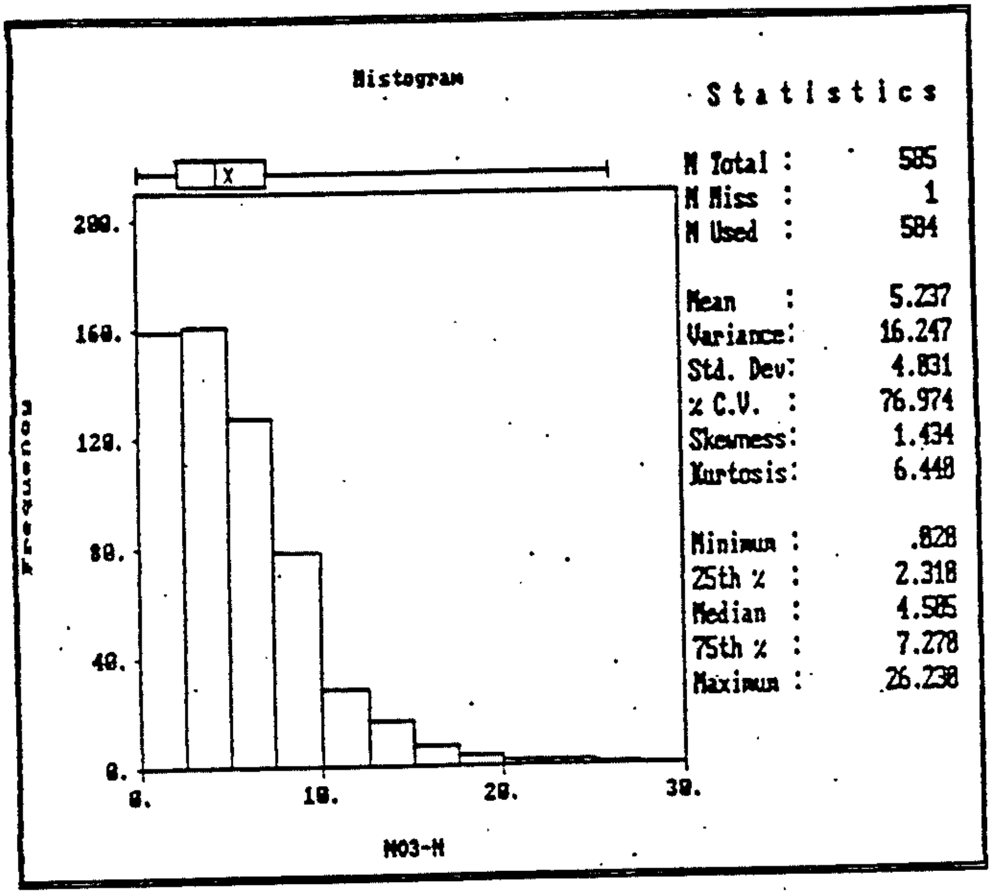


Figure 19. Distribution of nitrate-nitrogen values, NDEC WUBB SPA Study.

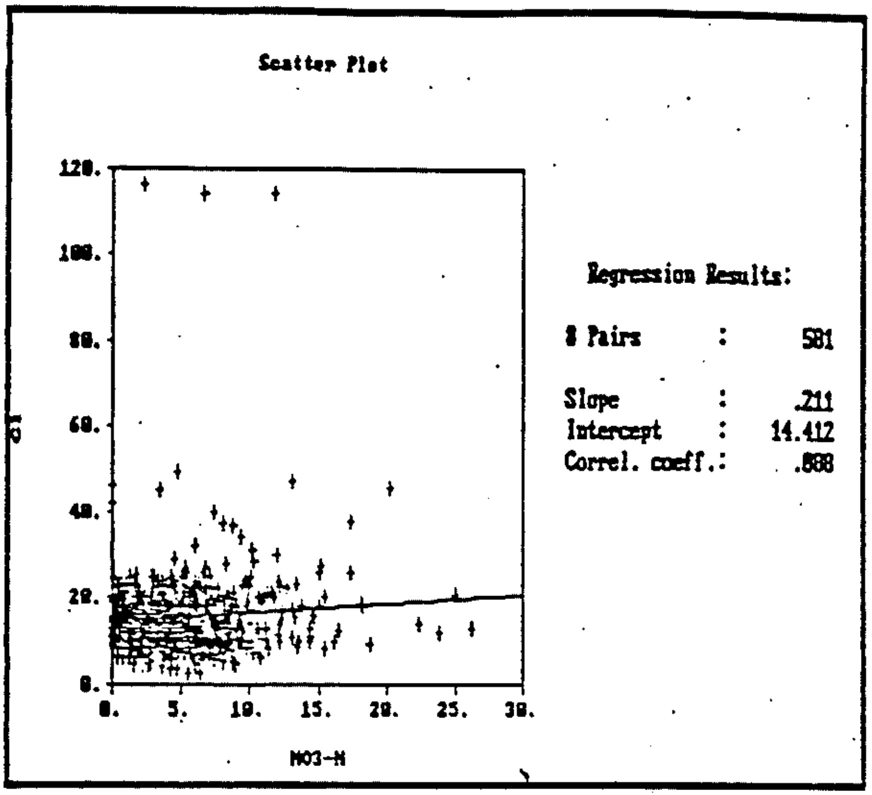


Figure 20. Correlation between nitrate-nitrogen and chloride concentrations NDEC WUBB SPA Study, 1991.

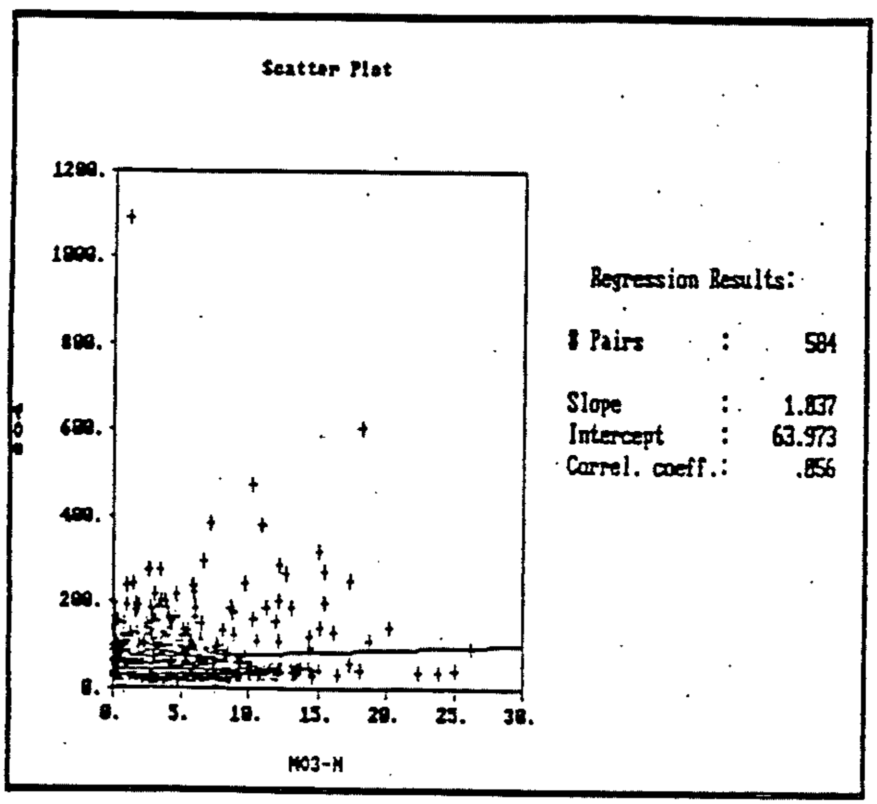


Figure 21. Correlation between nitrate-nitrogen and sulfate concentrations NDEC WUBB SPA Study, 1991.

low nitrate values, lack of variability, and the lack of outliers indicate sampling results are probably representative of regional conditions.

Table 9 presents NDEC sampling results for wells sampled both in 1990 (Gottula, 1991) and in 1991. No trend is evident from this data. The large change in nitrate-nitrogen concentration in the well located at 11N2W26ba may be caused by point source contamination, sampling, and/or analysis error(s).

Appendix E contains results for samples tested for pesticides. A total of 17 samples were analyzed for the presence of pesticides. Ten were screened for 19 pesticides, the remaining seven were analyzed for atrazine only. Atrazine was quantified in eight samples, all at low levels, the highest concentration being 0.447 ug/l. The maximum contamination level (MCL) for atrazine is 3 ug/l. No other pesticide was detected.

TABLE 9
NDEC Sampled Wells in 1990 and 1991

County	Location	1990 Sample No.	1990 NO_3-N (mg/l)	1991 Sample No.	1991 NO_3-N (mg/l)	Difference (mg/l)
Polk	13N1W7bo	69	5.85	P49	6.19	+0.34
York	9N2W11ac	58	5.96	Y25	3.00	-2.96
York	9N3W32cb	57	10.0	Y148	9.03	-0.97
York	9N4W1bc	40	1.80	Y16	1.72	-0.08
York	10N2W13dc	41	6.90	Y154	9.28	+2.38
York	10N2W22aa	63	5.98	Y117	7.00	+1.02
York	10N3W19cc	38	6.48	Y14	6.13	-0.35
York	10N3W26bb	62	9.16	Y84	8.44	-0.72
York	10N4W7co	54	2.08	Y92	3.32	+1.24
York	11N2W12cc	65	5.23	Y137	7.09	+1.86
York	11N2W26ba	47	12.2	Y48	2.12	-10.08
York	11N2W34dc	64	12.1	Y4	12.0	-0.10
York	12N2W12aa	49	3.50	Y54	3.83	+0.33
York	12N2W14ca	50	3.73	Y52	4.26	+0.53
York	12N3W8cc	71	3.37	Y36	3.92	+0.55
York	12N3W15ao	51	5.04	Y35	6.07	+1.03
York	12N4W4ao	73	5.83	Y102	6.66	+0.83
York	12N4W12bb	72	6.17	Y67	8.60	+2.43
York	12N4W17do	52	2.45	Y101	2.13	-0.32
York	12N4W30bc	53	7.65	Y99	6.17	-1.48

York Ground Water Recharge Demonstration Project

Information from the York Ground Water Recharge Demonstration Site supports study area sampling results. Piezometric and chemical differences between two aquifers underlying the site illustrates the effective separation of aquifers that can occur in UBBNRD. Nitrate-nitrogen concentrations in water from the lower aquifer were below the Method Detection Limit (MDL) while water from the upper aquifer had much higher nitrate-nitrogen concentrations before recharging activities began at the site. As nitrates infiltrate downward to aquifers the impact to ground water will be seen first in uppermost portions of water-bearing rocks. Except for a small portion of the southeast corner of the site, fertilizers were not known to be applied at the site (DeBuhr, personal communication). The presence of nitrates in the upper aquifer is indicative of lateral flow within the upper aquifer flow system. The incongruent nitrate-nitrogen levels in wells screened in different aquifers is similar to sampling results in other areas of UBBNRD with multiple aquifers.

The site is surrounded by eight sets of monitoring wells (Appendix G). Each set consists of one well screened in the upper (middle Pleistocene) aquifer and one well screened in the deep (lower Pleistocene) aquifer. The two aquifers are separated by approximately 70' of fine-grained sediments. The monitoring wells are of documented construction and are built to produce water from specific geologic intervals. Water-level fluctuations in the two aquifers exhibit a lack of hydraulic connection (Appendix G).

Monthly sampling of seven of the eight sets of monitoring wells for major ions plus nitrate-nitrogen was initiated by NDEC and UBBNRD to provide possible seasonal information for this study. Monthly sampling began before recharge activities began in June, 1990 and ended December, 1991. Appendix G contains a site diagram, an example of water-level fluctuations, graphs of ion concentration fluctuations in shallow and deep wells, and trilinear diagrams for major ions.

Generally the ionic composition in both aquifers is very similar but there are distinct differences. Field measurements indicate that the shallow water is generally colder and slightly basic relative to the deeper water. Electrical conductivities of water in deep wells generally range from 300 to 400 uhmo/cm while water in shallow wells have much more variable conductivities. Shallow monitoring wells 1A, 2A, and 8A tend to have lower conductivities than their paired deeper wells while the remainder have higher conductivities relative to their paired deeper wells.

Ionic concentrations are areally and temporally variable in the shallow wells, while the deep wells are not nearly as variable in either respect. The effect of recharging waters became apparent during the Spring of 1991 by the increasing fluctuations in almost all ionic constituents. A large runoff event in early June, 1991 may be responsible for the convergence of the shallow well water's ionic constituents during the Summer of 1991. The effect of recharging waters negated or obscured analysis for seasonal fluctuations.

Separation of aquifers is also evident from nitrate-nitrogen concentrations. The deep wells have nitrate-nitrogen levels below method detection limits (0.02 mg/l). Shallow wells have nitrate-nitrogen concentrations that are variable both areally and temporally. The effects of recharge on some aspects of water quality are difficult to evaluate at this time. One observation is that the lake water has low nitrate-nitrogen concentrations and may be the cause for several shallow monitoring wells having significantly lower nitrate-nitrogen levels a the end of monthly sampling (Dec. 1991) conducted by NDEC.

DISCUSSION

Study results from EUBB and WUBB indicate that ground water quality in the UBBNRD is generally good, especially in areas with thick and areally extensive aquifers and/or aquifers that are relatively isolated. However, different water qualities are evident in multiple aquifer settings and contamination by nitrate is evident. Most of the elevated nitrate-nitrogen concentrations occur in uppermost aquifers or in areas with relatively small aquifers of low storage available for dilution.

Nonpoint source contamination in Nebraska has often been associated with well drained to excessively well drained soils, irrigation, corn production, and the application of fertilizers, pesticides, and animal wastes (Spalding and Exner, 1988). The Hastings soils that occur on uplands are well drained. These soils have high shrink-swell potential and under certain conditions, can crack and rapidly transmit contaminants to the underlying sediments. Corn production, irrigation, and the application of fertilizer, pesticides, and animal wastes are common throughout UBBNRD's Groundwater Control Area.

Irrigation wells comprised 96% of all sampled wells. Sampling results indicate that very few of the wells are influenced by point source contamination. Lack of point source influences does not necessarily imply the well is good for detecting nonpoint source contamination. Irrigation wells are built for the best possible yield and well construction techniques often include placing gravel packs along the entire length of well casing and screen. This practice was common through the early 1980s and often results in co-mingling of aquifer waters. The blending of waters can mask the magnitude of contaminant loading of ground water. In areas where large volume aquifers occur, accurate quantification of contamination is difficult without an understanding of flow systems and vertical stratification.

Areas with elevated nitrate contaminations include a band near Lincoln and Beaver Creeks through central York and Hamilton Counties, northern Hamilton County, along the northwest and southwest study area boundaries, and in north-central Fillmore County. The geologic setting for each area can explain much of this areal variation.

The band through central York County is a composite of two different settings. West-central York County in the vicinity of Bradshaw exhibits high bedrock resulting in a limited aquifer. East of that area a glacial till and associated fine-grained sediments separate aquifers. The separation continues eastward into central Seward County to the vicinity of Goehner where only the upper aquifer continues east to the valley of the Big Blue River. Wells were differentiated by aquifer in a portion of EUBB (Gottula, 1990). In the adjacent area of east central York County, almost all wells are screened in the upper or in both upper and lower aquifers. Elevated nitrate-nitrogen concentrations are common in wells screened in the upper aquifer. The few wells screened in lower aquifers have water with low levels of nitrate. Water exhibiting a composite nitrate-nitrogen concentration is found in wells screened in both units. Thus, in areas with multiple aquifers nitrate-nitrogen concentrations in water sampled from wells screened in different aquifers can appear heterogenous, until sampling results are separated by water sources.

North-central Fillmore County also has separated aquifers, but here the upper water is perched. When a well is open to perched water, and upper water falls through the casing to the lower aquifer, drillers often refer to this as "cascading water". Some of the highest nitrate-nitrogen concentrations occur in this area. The perched water may contain high amounts of nitrate-nitrogen. Point source contamination may be a factor here but the perched water is naturally highly mineralized and outliers are not as evident.

The elevated nitrate concentrations along the northwestern and southwestern boundaries, the

Goehner to Seward area in EUBB, and, to some extent, northern Hamilton County all have relatively limited aquifers. High nitrate concentrations in northern Hamilton County are not easily explained.

Areas in UBBNRD with low nitrate concentrations are usually associated with alluvial aquifers, large aquifer volumes, and confined conditions. Examples of areas with low nitrate concentrations and large aquifer volumes include the Geneva area in central Fillmore County, and the northeast boundary of the study area in Polk County. Wells screened in alluvial aquifers in the relatively narrow valleys have low nitrate concentrations possibly due to dilution from surface waters. Confined aquifers in southeastern York County have low nitrate-nitrogen concentrations.

There are many exceptions for the previous generalizations. For example, southwestern Hamilton County, and northeast Clay-northwest Fillmore Counties have limited aquifer volumes, and low nitrate-nitrogen levels.

Regulatory Concerns

SPA studies are conducted to determine if nonpoint source contamination is occurring or has the potential to occur, and to identify those areas both geographically and stratigraphically. The regional and diffuse character of nonpoint source contamination makes detection difficult. Often, technical information is not detailed enough to accurately delineate a specific aquifer, or the boundary of contaminated ground water. In addition, delineation of SPAs is not wholly technical, for example, administrative needs require delineation along established legal boundaries.

This study concludes a three year investigation (Gottula, 1990; 1991) of ground water quality in UBBNRD. Nonpoint source contamination is evident in portions of the district. Other areas of the district are probably experiencing nonpoint source contamination, but it is difficult to detect and/or document by sampling irrigation wells. Land use practices with potential for causing nonpoint source contamination are common throughout the established Ground Water Control Area which covers over 95% of the district's area.

Given the complex geologic and hydrogeologic conditions existing in the UBBNRD, the following management options were considered:

1. An SPA could be designated where there is evidence of nonpoint source contamination and no alterative water supply exists. This SPA would recognize the real problem water users experience in these areas but would not deal with all areas where evidence of nonpoint source contamination exists. Several small SPAs would result that would be difficult to delineate geographically and administer efficiently. Stratigraphic delineation would include all potable water sources.
2. An SPA could be designated in all areas where there is evidence of nonpoint source contamination. This SPA would recognize areas with evidence of nonpoint source contamination. However, such a designation would not address areas where contamination is occurring and evidence is lacking, or areas with potential for nonpoint source pollution due to land use practices. Stratigraphic boundaries would include contaminated aquifers that would be difficult to delineate geographically and stratigraphically.
3. An SPA could be designated where nonpoint source contamination has occurred or is likely to occur in the reasonably foreseeable future. This SPA would address all evident and potential nonpoint source contamination and would include nearly if not all, the entire UBBNRD. Such an SPA could include areas where nonpoint source contamination may not occur. Geographic boundaries would be established along current NRD boundaries, and stratigraphic boundaries based on potential for nonpoint source contamination would include all aquifers supplying potable water. The district could recognize the differing conditions within the SPA and tailor their action plan to those areas using a phased approach.

CONCLUSIONS

Sampling results indicate contamination by nitrates is occurring in aquifers within the study area. Most areas with evidence of contamination are characterized by multiple aquifers or aquifers of limited ground water in storage (low dilution potential). Virtually the entire UBBNRD has the following characteristics associated with nonpoint source contamination of ground water:

1. Nitrogen sources available (applied fertilizers and animal wastes).
2. Potential for leaching of nitrates (permeable soils and subsurface materials, crops requiring relatively intense fertilization).
3. Mechanism for transport (deep percolating water from precipitation and irrigation water).

Elevated nitrates in the vadose zone beneath corn fields is good evidence of leaching beneath the root zone. Regional contamination is evident by elevated, relatively homogenous nitrate-nitrogen concentrations in wells screened in uppermost aquifers and in areas with relatively little dilution potential.

RECOMMENDATIONS

These recommendations encompass the entire UBBNRD, utilizing the results and conclusions of this study, and the two previous SPA studies conducted in UBBNRD (Gottula, 1990; 1991).

Evidence of nonpoint source contamination occurring or likely to occur in almost the entire Upper Big Blue Natural Resources District has been presented in this report and the previous two SPA reports (Gottula, 1990; 1991). Therefore, the NDEC recommends designation of a Special Ground Water Protection Area for the entire NRD (see Figure 22). Stratigraphically, this SPA should include sediments from the ground surface downward through all aquifer units supplying potable water. This would include Cenozoic and Cretaceous sediments and bedrock units as defined by the Nebraska Conservation and Survey Division.

Such a designation will allow the UBBNRD to take steps necessary to reduce and prevent further nonpoint source contamination from occurring. The designation will also allow the NRD to administer a ground water quality program with the most efficiency. The areas of the district with the greatest problems can be targeted with specialized plans appropriate to their local conditions. Likewise, those areas with fewer current problems can be targeted for preventive efforts. The plan to address the nonpoint source problem can be tailor-made to fit local geologic conditions with the greatest amount of flexibility.

The development of the action plan for this SPA will include a monitoring program. In implementing this monitoring program, UBBNRD may wish to consider such measures as sampling of irrigation, domestic, and municipal wells, installation and sampling of dedicated monitoring wells, soil coring, or other appropriate activities, as resources will allow. Such activities will help to improve the understanding of subsurface geologic, hydrogeologic, and water quality conditions.

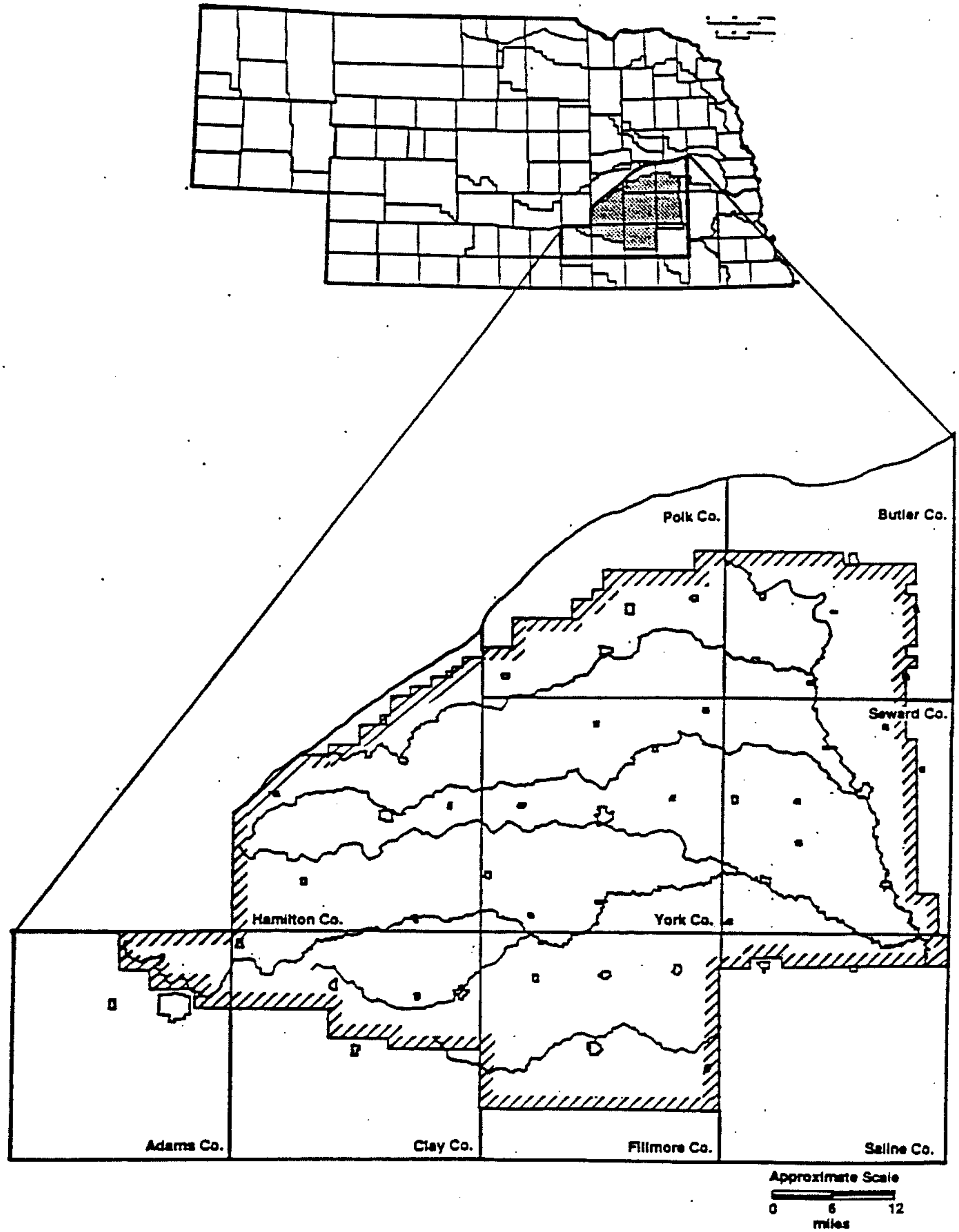


Figure 22. Proposed boundary for Special Protection Area, UBBNRD.

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Appendix A. Request for SPA Study from UBBNRD

UPPER BIG BLUE
Natural Resources District
105 Lincoln Ave.
York, Nebraska 68467
(402) 362-6601

DC/Dick

April 21, 1989

Mr. Dennis Grams, Director
Department of Environmental Control
301 Centennial Mall South
Box 94877
State House Station
Lincoln, NE 68509

RECEIVED
APR 25 1989
DEPT. OF ENVIRONMENTAL CONTROL

Dear Mr. Grams:

At it's April 20, 1989 meeting the Upper Big Blue Natural Resources District Board of Directors took action supporting the City of Seward's request for a Special Protection Area study and further requests that the Department of Environmental Control study the entire Upper Big Blue NRD.

As you may know the district has met with Seward officials and with Dick Ehrman and Marty Link of your staff to discuss the SPA study possibilities. We realize that it is not practical for your staff to study the entire district at one time, however, we do feel that the entire district merits study over the next few years. Dick Ehrman and I have already discussed what appears to me at this point to be a practical study area in response to Seward's request.

We look forward to meeting with your staff to discuss how the remainder of the district should be divided for studies in the future.

Sincerely,

Rodney DeBuhr
Rodney DeBuhr
Water Department Manager

RD:nd
pc: Don Eikmeier, Seward City Administrator
Gordon Kissel, NARD

Appendix B. Request for SPA Study from City of Seward

DC/DE

City of SEWARD

Government of, by, and for the people

Phone 402-643-2928 • P.O. Box 38 • 537 Main Street • Seward NE 68434

November 2, 1988

RECEIVED

NOV 3 1988

DEPT. OF ENVIRONMENTAL CONTROL

Dennis Grams, Director
Department of Environmental Control
301 Centennial Mall South
Lincoln, Nebraska 68508

The City of Seward respectfully request that your department initiate the process that is necessary to determine if the area of the City of Seward well fields meet the necessary requirements as a Special Ground Water Protection Area as allowed by LB 894.

The City of Seward well fields have had a dramatic increase in contamination of the water by nitrates. The average nitrate content of our west well field in 1972 from samples of six wells was 3.03 PPM. These same wells in 1988 have an average nitrate content of 10.5 PPM. One well that had a nitrate content of 2.6 PPM in 1972 now has tested over 15 PPM. The production of water from the west field was 287,105,200 gallons in 1972 and 145,528,000 gallons were pumped in 1987. Our south well field nitrate levels range from 3.7 PPM to 5.4 PPM and have shown an increase in relation to the amount of water pumped. However, the south well field has limited capacity and can not supply the amount of water required by the city.

In 1987 the City installed two new wells and three and one-half miles of water mains to connect this new well field to our west well field giving us the ability to mix the water and maintain the level of nitrates in the system at a level acceptable to the Health Department.

The nitrate levels of the new well field are at acceptable levels at present. However, this is with limited pumping. We will have to monitor these wells as pumping is increased to meet the demands of the system. Domestic wells in the area of our new wells have shown nitrate levels of over 30 PPM.

The City of Seward realizes the importance of providing safe drinking water to all patrons of the water system. By planning and funding new water projects, the City will strive to provide good safe water. However, finding water of sufficient quantity and quality in Seward County is becoming a problem that could affect the growth and development of all of Seward County.

Thank you for your time and consideration of this letter. If more information is needed please feel free to contact me.

Sincerely,

Fred J. Welsh
Mayor

Appendix C. UBBNRD Vadose Zone Lithologic Core Logs

BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-1	N ½ SE ¼ 27 T11N R2E			KC	RK

WATER LEVEL OBSERVATIONS: WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	___ HOURS	TYPE OF SURFACE	DRILL RIG
67.0'	67.8" Wet Cave			Cornfield	GEO 88

DRILLING METHOD	TOTAL DEPTH
6" Continuous Flight Auger	75.0'

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS/FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft.
	SS-1			Dk Br	Moist	Fir-	Topsoil, w/ roots, highly organic		9.6	(CL)	
	SS-2			Lt Br	Moist	Stiff	PEORIAN LOESS horizontal layering rust & carbon stains		1.4		
	SS-3								0.9		
	SS-4								0.7		
5	SS-5								0.8		5
	SS-6				VMoist				5.3		
	SS-7								6.4		
	SS-8								5.9		
	SS-9								5.4		
10	SS-10								5.0		10
15	SS-11								5.4		15
20	SS-12			Red-Br	Moist	Stiff	LOVELAND LOESS w/ horizontal layering carbon & rust stains w/ calcium magnesium nodules		5.6		20
25	SS-13			Dk Br					4.5	(CL-CH)	25
30	SS-14			Red-Br		Very Stiff			2.5		30
35	SS-15								2.3		35

GS Geotechnical Services Inc.

Project	
NRD Nitrate Study	
Location	
Seward County, Nebraska	
Job No.	Date
1805228	11/29/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-1	N ½ SE ¼ 27 T11N R2E			K.C.	RK

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST.	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP. FT.
40	SS-16			Red-Br.	Moist	Stiff	silty sandy clay Alluvial Deposits		1.8	(SC)	40
45	SS-17						Relatively clean fine sand		1.7	(SP)	45
50	SS-18								1.6		50
55	SS-19						coarser than before		1.8	(SP-SW)	55
60	SS-20								1.3		60
65	SS-21				V.Moist				1.2		65
70	SS-22				Wet				4.9		70
75	SS-23			Lt Gray		Very Stiff	w/ calcarious concretions magnesium nodules Bottom of Hole 75.0'		3.6	(CH)	75

Geotechnical Services Inc.

Project	NRD Nitrate Study
Location	Seward County, Nebraska
Job No. 1805228	Date 11/30/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-2	SE ¼ SE ¼ 32 T11N R1E			K.C.	R.K.

WATER LEVEL OBSERVATIONS: WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	___ HOURS	TYPE OF SURFACE	DRILL RIG
90'	90' Wet Cave			Cornfield	GEO 88

DRILLING METHOD	TOTAL DEPTH
6" Continuous Flight Auger	95'

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS
	SS-1			Drk. Br	Moist	Firm	Top soil, roots highly organic, silty clay		16.4	
	SS-2								4.4	
	SS-3			Gray Br			silty clay, fat clay, colluvium, iron, calcium nodules		2.7	
	SS-4								4.4	
5	SS-5								4.9	
	SS-6								4.6	
	SS-7								5.8	
	SS-8				Very Moist				6.4	
	SS-9								6.5	
10	SS-10								6.4	
	SS-11			Lt. Br			Peorian Loess, less clay than before, more iron nodules, rust stains		6.9	
15										
	SS-12			Lt. Gray			unweathered Peorian, less rust		7.5	
20										
	SS-13						saturated 2' above Loveland		5.0	
				Red-Br			Loveland Formation, sand seams very fine, sand scattered throughhour silty, sandy clay, rust stains 26			
25										
	SS-14			Olive Brn	Moist	Hard	glacial till, fat clay, Kansas till, silty, sandy clay, carbon stains, hard to drill, blocky 30		2.8	
30										
	SS-15					Firm	silty clay, poorly graded fine sand		3.4	
35										

Geotechnical Services Inc.

Project	NRD Nitrate Study
Location	Seward County, Nebraska
Job No.	1805228
Date	12/10/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-2	SE ¼ SE ¼ 32 T11N R1E			K.C.	R.K.

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEPTH FT
40	SS-16				Very Moist		silty, sandy clay, small blocky texture, very fine sand mixed in clay		3.8		40
45	SS-17			Drk. Gr.		Hard	Back to till, some unweathering fat clay, water in cracks		3.2		45
50	SS-18					Firm	Fine sand, poorly graded		3.5		50
55	SS-19						1' clay seam, very rusty 53'		3.1		55
60	SS-20				slightly Moist		Well-graded, more rust, coarse sand scattered, pieces of gravel, rounded stream, rolled sands, gravels of the early Pleistocene Alluvium		1.4		60
65	SS-21								1.6		65
70	SS-22								1.2		70
75	SS-23								1.3		75

GS Geotechnical Services Inc.

Project: NRD Nitrate Study	
Location: Seward County, Nebraska	
Job No. 1805228	Date 12/10/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-2	SE ¼ SE ¼ 32 T11N R1E			K.C.	R.K.

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft
80	SS-24			Lt. Br			clayey, silty sand, fine coarse sand throughout		2.6		80
85	SS-25						poorly graded sand, well-graded seams up to 1' thick		2.5		85
90	SS-26								2.2		90
95	SS-27				Wet				1.9		95
100	SS-28								1.6		100
105							Bottom of Hole 95'				105
110											110
115											115

Geotechnical Services Inc.

Project	NRD Nitrate Study		
Location	Seward County, Nebraska		
Job No.	1805228	Date	12/10/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-3	SE ¼ 24 T11N R2W			K.C.	R.K.

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	___ HOURS	Cornfield	GEO 88
				DRILLING METHOD	TOTAL DEPTH
62'	62.8'			6" Continuous Flight Auger	65'

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft.
	SS-1			Drk. Brn	V Moist	Firm	1' Top Soil highly organic		13.2		
	SS-2			Lt. Brn			Peorian Loess, silty clay, rust, carbon stains, mottling poorly drained area		2.6		
	SS-3								1.8		
	SS-4								2.0		
5	SS-5								1.4		5
	SS-6								2.4		
	SS-7								2.8		
	SS-8								2.9		
	SS-9								2.8		
10	SS-10								3.2		10
15	SS-11						No more mottling		2.3		15
20	SS-12						Horizontal layering, iron nodules		2.2		20
25	SS-13			Red-Brn	Moist		Loveland Formation, alluvium silty, sandy clay, with sand seams up to .5 thick rust, fine sand, poorly graded magnesium nodules, small block texture		2.2		25
30	SS-14			Lt. Red Brown		Hard			1.7		30
35	SS-15						No more sand seams, fat clay, sandy, silty clay		1.5		35

Geotechnical Services Inc.

Project	
NRD Nitrate Study	
Location	
York County, Nebraska	
Job No.	Date
1805228	12/13/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-3	SE ¼ 24 T11N R2W			K.C.	R.K.

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP FT.
40	SS-16			Red-Brn	Moist		Occasional pebble of coarse rounded sand		2.2		40
45	SS-17								2.0		45
50	SS-18					Firm	silty, sandy clay changing to a silty, clayey sand at 49'		1.4		50
55	SS-19						Fine sand with occasional coarse pebble, poorly graded, rust		1.4		55
60	SS-20						Well-graded sand with small clayey seams, lots of rust		1.8		60
				Olive Gr.		Hard	Glacial till, Kansas till, fat clay, scattered sand throughout, seams of fine sand bearing water, iron nodules, carbon stains, perched water				
65	SS-21				Wet				2.1		65
70							Bottom of Hole 65'				70
75											75

GS Geotechnical Services Inc.

Project	
NRD Nitrate Study	
Location	
York County, Nebraska	
Job No.	Date
18 05528	12/13/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-4	SE ¼ 21 T13N R2W			K.C.	R.K.

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	___ HOURS	Cornfield	GEO 88
				DRILLING METHOD	TOTAL DEPTH
73'	73'			6" Continuous Flight Auger	80'

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft.
	SS-1			Black	Moist	Firm	1' Top soil, roots highly organic		32.2	silty clay	
	SS-2			Lt. Brn			Peorian Loess, fat clay, horizontal layering, carbon stains		24.3		
	SS-3								14.9		
	SS-4								4.2		
5	SS-5								4.4		5
	SS-6						Less clay than before lean clay		3.2		
	SS-7								2.7		
	SS-8								2.7		
	SS-9								1.9		
10	SS-10								1.9		10
15	SS-11						Few rust stains, more carbon		1.9		15
20	SS-12								1.7		20
25	SS-13				Very Moist				1.6		25
30	SS-14			Drk. Red Brown	Moist		Loveland Loess, silty clay, more clay than before horizontal layering, texture getting blocky		3.6		30
35	SS-15			Lt. Red Brown	slightly Moist				3.1		35

GS Geotechnical Services Inc.

Project	NRD Nitrate Study
Location	Polk County, Nebraska
Job No.	1805228
Date	12/11/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-4	SE ¼ 21 T13N R2W			K.C.	R.K.

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP FT.
40	SS-16				Moist		magnesium nodules		3.2		40
45	SS-17				slightly Moist		silty, sandy clay, very fine sand; silty clay		2.5		45
50	SS-18						silty, sandy clay, changing to clayey silty sand, fine poorly graded at 52'		2.4		50
55	SS-19								1.3		55
60	SS-20			Olive Gr.			silty clay, fat clay, small seams of fine sand, Loveland Formation Alluvium		2.4		60
65	SS-21				Very Moist	Hard	Larger sand seams than before		4.3		65
70	SS-22			Lt. Olive Gray	Moist		Glacial till, Kansas till, very stiff, blocky texture large calcarious concretions, seams of calcium, silty sandy clay, perched water, seams of fine sand poorly graded up to 5' thick		3.2		70
75	SS-23				Wet				3.1		75

GS Geotechnical Services Inc.

Project: NRD Nitrate Study
Location: Polk County, Nebraska
Job No.: 1805228
Date: 12/11/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-4	SE ¼ 21 T13N R2W			K.C.	R.K.

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft.
	SS-24								2.3		
80											80
							Bottom of Hole 80'				
85											85
90											90
95											95
100											100
105											105
110											110
115											115

GS Geotechnical Services Inc.

Project: NRD Nitrate Study
Location: Polk County, Nebraska
Job No.: 1805228
Date: 12/11/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-5	SE ¼ 33 12N R7W			KC	RK

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	___ HOURS	Cornfield	GEO 88
				DRILLING METHOD	TOTAL DEPTH
96	96			6" Continuous Flight Auger	100.0

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP. FT.
	SS-1								4.2	(CL)	
	SS-2			Dk Br.	Moist	Firm	Topsoil highly organic		2.3		
	SS-3			Lt Br.			PEORIAN LOESS		1.7		
	SS-4						w/ calcarious concretions		1.8		
5	SS-5						Rust and carbon stains		1.3		5
	SS-6						Horizontal Layering		3.1		
	SS-7						Weathered with gray		2.6		
	SS-8						Unweathered streaks		1.9		
	SS-9								2.3		
10	SS-10								2.4		10
	SS-11								1.8		
15											15
	SS-12				V.Moist		Perched water atop the Loveland formation soils.		3.1		
20											20
	SS-13			Red-Br.	Moist		LOVELAND LOESS increasing clay content		2.9		
25											25
	SS-14			Lt Red-Br.			silty clayey sand, fine - poorly graded		2.6	(SC-CL)	
30											30
	SS-15						silty clay		2.1	(CL)	
35											35

GS Geotechnical Services Inc.

Project	
NRD Nitrate Study	
Location	
Hamiliton County, Nebraska	
Job No. 1805228	Date 11/26/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-5	SE¼ 33 12N R7W			KC	RK

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP FT.
40	SS-16			Red-Br / Olive Gr	Moist	Firm	Loveland w/ more sandy seams up to 2' thick		3.1	(CL)	40
45	SS-17								2.5	(SC)	45
50	SS-18			Lt Br			fine poorly-graded sand		2.0		50
55	SS-19						fine sand, poorly graded		1.9	(SP)	55
60	SS-20								2.5		60
65	SS-21								2.6		65
70	SS-22								2.9		70
75	SS-23			Red-Br			Large rust stains mixed evenly in clay sand mix, some sandy seams		5.4	(SC)	75

GS Geotechnical Services Inc.

Project	NRD Nitrate Study
Location	Hamilton County, Nebraska
Job No. 1805228	Date 11/26/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-5	SE ¼ 33 12N R7W			K.C.	R.K.

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS/FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP. FT.
	SS-24			Red-Lt Br	Moist	Firm	Iron Nodules		2.8	(CL)	
80	SS-25						Back to fine sand		2.2	(SP)	80
85	SS-26								2.5		85
90	SS-27								2.5		90
				Multi-Colored	Sat.	Firm	Pleistocene Age Alluvium sands and gravel			(SW)	
95	SS-28								1.6		95
100							Bottom of Hole 100.0'				100
105											105
110											110
115											115

Geotechnical Services Inc.

Project	
NRD Nitrate Study	
Location: Hamilton County, Nebraska	
Job No. 1805228	Date 11/26/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-6	SW ¼ 26 T8N R3W			K C	R K

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	HOURS	Cornfield	GEO 88
				DRILLING METHOD	TOTAL DEPTH
48'	48'			6" Continuous Flight Auger	60'

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft.
	SS-1						Top soil, roots, highly organic		13.3	(CL)	
	SS-2			Drk Br	Moist	Firm			8.7		
	SS-3			Lt. Br	Moist	Firm	PEORIAN LOESS w/ rust and carbon stains Lrg. calcarious concretions iron nodules		4.5		
	SS-4								2.0		
5	SS-5								4.2		5
	SS-6								5.6		
	SS-7								5.2		
	SS-8								4.5		
	SS-9								4.6		
10	SS-10								4.7		10
	SS-11						More Iron than before		5.5		
15	SS-12								5.4		15
				Red-Br	Moist	Firm	LOVELAND FORMATION silty, sandy clay sand dispersed evenly iron stains magnesium nodules				
20	SS-13								3.3		20
25	SS-14			Olive gr.	Moist	Very Stiff	KANSAS TILL w/ calcarious concretions highly expansive		4.9	(CL-CH)	25
30	SS-15						A sand seam from 31' to 35'		3.8		30
35											35

GS Geotechnical Services Inc.

Project	
NRD Nitrate Study	
Location	
Fillmore County, Nebraska	
Job No.	Date
1805228	11/27/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-6	SW ¼ 26 T8N R3W			K.C.	R.K.

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft.
40	SS-16			Olive Gray	Moist	Very Stiff			4.0		40
45	SS-17						1' sand seam from 40' to 41'		3.4		45
50	SS-18						Many calcarious seams up to 5' thick. Larger calcarious concretions, up to 1" in diameter		3.2		50
55	SS-19				Wet*		Some perched water		4.3		55
60	SS-20						Bottom of Hole 60'		3.6		60
65							* Perched Water				65
70											70
75											75

Geotechnical Services Inc.

Project: NRD Nitrate Study

Location: Fillmore County, Nebraska

Job No.: 1805228

Date: 11/27/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-7	E ½ NE ¼ 22 T11N R2E			K.C.	R.K.

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	HOURS	Pasture	GEO 88
				DRILLING METHOD	TOTAL DEPTH
78.5	78.5 Wet Cave			6" Continuous Flight Auger	80'

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft.
	SS-1			Drk. Br	slightly moist	Firm	1' Top soil grass, roots		2.6		
	SS-2								1.0		
	SS-3			Lt. Br			Peorian Loess, lean clay, rust, carbon stains, root holes, horizontal layering		1.0		
	SS-4								1.0		
5	SS-5								0.9		5
	SS-6								1.0		
	SS-7								0.8		
	SS-8								0.7		
	SS-9								0.7		
10	SS-10								0.7		10
	SS-11				Moist				0.8		
15											15
	SS-12								0.9		
20											20
	SS-13			Red-Br			Loveland Loess, more clay than before, some very fine sand mixed in		1.2		
25											25
	SS-14								2.1		
30											30
	SS-15								1.5		
35											35

GS Geotechnical Services Inc.

Project: NRD Nitrate Study

Location: Seward County, Nebraska

Job No. 1805228

Date 11/30/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-7	E ½ NE ¼ 22 T11N R2E			K.C.	R.K.

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft.
				Red-Br	Moist	Firm					
40	SS-16			Lt. red-Br			Loveland Formation, silty sandy clay, fine sand with occasional pebble rounded Alluvium		1.3		40
45	SS-17						sand fine, poorly graded with coarser seams .5' to 1' thick		0.9		45
50	SS-18						silty, sandy clay, course sand; sand, fine with coarser seams		1.2		50
55	SS-19						silty, sandy clay, sand well-graded		1.1		55
60	SS-20						sand well-graded		0.9		60
65	SS-21						sand, fine, poorly graded		0.6		65
70	SS-22						6" clay layer		0.9		70
75	SS-23						Well-graded		0.6		75

GS Geotechnical Services Inc.

Project	NRD Nitrate Study
Location	Seward County, Nebraska
Job No. 1805228	Date 11/30/90

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BORING LOG

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	DRILLER	LOGGER
DH-7	E ½ NE ¼ 22 T11N R2E			K.C.	R.K.

DEP. Ft.	SAMPLE NO. & TYPE	"N" BLOWS FT	% RECOV	COLOR	MOIST	CONSIST	GEOLOGIC DESCRIPTION & OTHER REMARKS	% MC	Nitrate Nitrogen ppm	CLASS	DEP Ft.
	SS-24								1.0		
80							Bottom of Hole 80'				80
85											85
90											90
95											95
100											100
105											105
110											110
115											115

GS Geotechnical Services Inc.

Project: NRD Nitrate Study

Location: Seward County, Nebraska

Job No.: 1805228

Date: 11/30/90

Form 216 3 1/89

Appendix D. Sampling Form

Upper Big Blue SPA Study

SAMPLE NO. SUB-________

SAMPLING DATA

BLANK/DUPLICATE/PEST/SPLIT

Date:________91 Time: ________

Sampled by ______________

LOCATION

UBBNRD (01) Legal T.___N., R.___W., Sec.____, ____1/4____1/4____1/4

Long________ Lat________ Reg. No.____________

Map______________ Hydro. Unit__________ Elev.__________

Regional Description: VAL UPL TER LCDEP DRAW

County: Y(185) P(143) F(059) H(081) C(035) A(001)

WELL

Type: Mun Irr Dom Stk Mon Other ____________________

Casing: Con Stl PVC Trans Other ____________________

Location: Pit Lowlying NearDrainage High

PIVOT/OTHER SPR GATE/DITCH ______________________________

Construction: Drl Drivn Dug Well Condition______________________________

Depth______ Screened Interval(s)________ ________ ________ Yield ________

Water Level _______ WL Date________ Pumping WL _______ Pump Depth ________

Date Drilled_______ (Approx. or Known) Time pumped before sample_____min.

Source of Info: Owner Reg Drlr Obs Other__________Logs available Y/N (Back)

Driller Name, Address:

POINT SOURCES

Barnyard ____ft.______ of well Active/Idle Cattle/Swine/Poultry/Horse/Other

Septic____ft.______ of well Uphill/Downhill

Other______________________________

NONPOINT SOURCES

Crops at well CRN SYB SHGUM ALFA BEAN SMGRN POTAT OTHER__________

Near well: (type.dis.dir)______________________________

Pesticides/Fertilizer used: (field.type.amount.app method.time)__________

____

FIELD DATA

Temperature_____°C Conductivity________umho/cm pH________

Hach NO_3-N_______mg/l Triazine POS NEG NA

LAB DATA NDEC lab/Other lab

COLIFORM POS NEG NA

	mg/l	meq/l		mg/l	meq/l	Pesticide
Nitrate-N	_____	_____	Sodium	_____	_____	type:__________
Chloride	_____	_____	Magnesium	_____	_____	conc:__________
Sulfate	_____	_____	Calcium	_____	_____	type:__________
Bicarbonate	_____	_____	Potassium	_____	_____	conc:__________
						type:__________
						conc:__________

Ionic Balance:__________%

WELL OWNER/OPERATOR

Name:______________________________ Results to be sent Y N

Address:

Appendix E. Lab Results

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
A001	8N9W27BCD	12	6.8	440	3.06	12.4	63	259.69	26.5	12	76.2	7	NA	I	149	
A002	8N9W29BBC	11.5	7.2	525	0.64	14.6	89.8-A	292.24	30.4	13.5	86.5	7.1	NA	I	130	1954
A003	8N9W20CBB	12	7.1	600	1.28-A	12.5	128	277.25	32.9-A	14.8	91.4-A	7.5	NA	I	145	1956
A004	8N9W23ACC	13	7	550	2.98	21.0-A	89.2	281.27	29.8	14.4	89.6	6.9	NA	I		1955
A005	8N9W35ADC	11.5	7	525	5.26	22.8	77.4	273.83	29.0-A	12.4-A	89.2-A	9.6-A	NA	I	185	1976
A006	8N10W25CCA	11	7.5	900	12.6	22.1	284	325.53	38.0-A	22	163	13	0.186*	I	156	
A007	8N10W34BCD	12	7.1	370	3.47	14	42	222.00	25	8.4	65	7.7	NA	I	192	1969
A008	8N10W27BBC	12	7.3	550	5.18	15	135	226.90	28	12.5	99.3	8.9	NA	I	170	1957
A009	8N10W17AO	13	7.1	600	3.21	10	154	244.00	24	13.3	106	9.9	NA	I	195	1980
A010	8N10W3ABC	12.5	7	650	2.94	21	166	300.10	30	16.5	125.6	12	NA	I	200	1956
A011	8N10W1ACB	12	7.1	350	0.29	10	60	217.20	21	8.4	64.6	8.3	NA	I	182	1977
A012	8N9W5CCC	13	7	490	0.09	8	136	244.00	32	13.6	97.9	7.7	NA	I	169	1987
A013	8N9W8BBB	13	7	460	0.27	11	84	256.20	25	14.3	95.9	8	NA	I	169	1986
A014	8N9W21CB	12	7.2	460	1.8	6	90	275.70	28	15.9	102.8	6.6	NA	I	145	1957
A015	8N9W33BO	13	7	550	7.66	22	98	278.20	31	16.6	122.8	8.1	NA	I	151	1975
A016	8N9W33ADD	13	7.1	500	5.49	14	91	278.20	28	14.2	110	8.7	NA	I		
A017	7N9W12CDC	13	6.9	650	17.27	26	56	353.80	44	16.6	126.8	8.4	NA	I	220	1989
A018	8N9W12BBC	13	7.2	800	2.62	15	274	302.60	37	22.5	170.5	11.7	NA	I	156	1983
A019	8N9W1CCC	14	7.2	825	17.28	38	249	263.50	36	24.9	170	7.6	NA	D		
A020	8N10W23DCB	13	7.1	700	3.91	18	121	309.90	33	12.8	101	10	NA	I	146	1970
A021	8N10W26BO	12	7.4	700	9.68	24	243	334.30	36	21.1	173.5	12.7	NA	I	160	1969
A022	8N10W27DO	12	7.5	525	5.88	21	85	251.30	32	11.9	93.6	8.9	NA	I	155	1973
A023	8N10W11BDC	12	7.2	700	1.7	18	198	290.40	47	15.6	133.4	10	NA	I	182	1972
C001	8N5W6BBA	11	6.9	500	8.23	18.6	51.9	284.81	21.7	13.8	85.5	6.4-A	NA	I	149	1972
C002	8N5W3DC	11	7.6	470	5.98	11.7	26.5	313.21	26.6	12.6	88.7	5.4	NA	I	152	1971
C003	8N5W1CA	11	7.7	550	8.05	14	28.1	319.43	26.3-A	13.5-A	94.4-A	5.2-A	NA	I	129	1975
C004	8N5W23BD	11	7.4	440	2.73-A	11.6	30	295.78	23.4	11.9	82.5	5.1	NA	I	171	1956
C005	8N5W17CC	11	7.5	470	4.91	18.1	38.7-A	303.95	25.6-A	12.5	86.6	6.7	NA	I	177	1967
C006	8N7W13BDC	12.5	6.9	460	3.58-A	20.7	73.1	221.77	20.1	13.3-A	72.5	8.3	NA	I	188	1971
C007	8N8W17ADB	13	7.1	500	1.96	16.1	107	264.08	27	14	90.3	8.4	NA	I	182	1979
C008	8N8W18BBB	14	7.2	600	5.69	22.1	108	315.53	34.2	15.6	108.7	9.2	NA	I	170	1969
C009	8N9W12DDB	13	7.2	700	2.47	20	140	346.01	38.7	17.2	121	10	NA	I		
C010	8N8W19DAC	13	7.2	491	3.72	14.8	92.6	257.50	27.7	13.8	82.6	6.7	U*	I	179	1964

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
C011	8N8W29DDB	13	7.1	500	3.42	16.5-A	98.6	236.16	26.9	13.6	82.1	7.2	NA	I	208	1974
C012	8N8W33CCA	13	7	490	3.98	17	79.6	236.04	22.4	11	82	8.2	NA	I	195	1985
C013	7N8W7ABD	13	7	490	4.55	28.9	43.5-A	252.01	28.4	10.4	78-A	7.5-A	NA	I	195	1955
C014	7N8W7ABA	13	6.9	525	13	47.4-A	36.9	236.04	26.8	13.4	86.8	8.4	NA	D		1957
C015	7N7W9BBC	13	7	525	4.8	15.2	106	270.78	31	14.1	94	8.1	NA	I	202	1966
C016	8N5W11ABA	11	7.3	460	4.84	9.55	25.6	320.89	21.8	13	84.5	5	NA	I	136	1956
C017	8N5W9BBA	11.5	7.3	460	4.25	17.0-A	24.9	296.39	20.6	12.4	81.5	5.2	NA	I	136	1973
C018	8N5W4CAC	11	7.3	390	2.76	18.8	30.2	234.70	18.1	10.9	66.8	5.2	NA	I		1957
C019	8N5W27AAC	11	7	420	2.35	15.8	26	270.78	19.7	11.4	72.9	5.8	NA	I	180	1975
C020	8N5W27AAA	11	7	360	0.23	16.9	30.8	227.50	17.2	9.6	62.3	5.7-A	NA	D		
C021	7N5W9BCD	11	7	370	3.62	12.3	45.1-A	202.63	24.2	11.2	54.3	5.9	NA	I	209	1970
C022	7N6W17ACA	11	7.3	600	2.65	16.1	88.0-A	264.57	25	13.8	88.3	6.6	NA	I	205	1970
C023	7N6W21AAC	11	7.3	470	0.71	22.8	74.4	248.72	31.3	11.6	74.1	5	NA	I	185	1956
C024	7N6W21DBC	11.5	7.2	440	0.23	17.9	67	249.94	29.3	11.3	71.5-A	4.9	NA	I	156	1975
C025	7N6W29DCD	11	7.3	900	20.2	45.5	139	327.23	77.2-A	15.7-A	118.3-A	6.7-A	NA	D	109	
C026	8N5W7AAA	14	7.1	800	9.45	23	32	319.60	30	13.2	96.4	6.1	NA	I	121	1974
C027	8N6W11DDB	13	6.9	650	5.25	21	50	241.60	22	12.4	83.4	5.6	NA	I	174	1968
C028	7N5W27ABB	13	7	600	1.33	25	28	239.10	26	11.2	69.6	5.5	NA	I	169	1973
C029	8N6W15CCB	13	7	650	2.01	21	74	239.10	20	8.3	87.8	6.5	NA	I	165	1957
C030	8N7W20DAB	13	7	650	4.14	22	80	229.40	26	12.1	83.3	7.3	NA	I		
C031	8N8W35BBD	13	7	650	2.31	21	109	229.40	27	13.1	93.4	6.9	NA	I	191	1955
C032	7N5W12CDD	12	7	390	4.62	15	51	195.20	22	11.4	74.4	5.9	NA	I		
C033	7N5W13BAD	12		350	2.09	12	37	217.20	16	11.9	79	5.3	NA	I	220	1957
C034	7N5W24CBA	13		400	1.65	20	57	217.20	30	11.5	69	5.2	NA	I	211	1964
C035	7N5W23CBB	13		420	3.94	23	50	229.40	34	12.6	80.6	6.3	NA	I	183	1967
C036	7N6W15CBA	13		480	0.04	46	88	275.70	29	14.1	102.2	7.7	NA		182	1975
C037	7N8W9ADC	13	7.2	450	7.37	40	41	236.70	24	13.7	102.9	6.9	NA	I	180	1957
C038	7N7W11BO	12	6.8	450	8.47	12	81	214.70	17	15.1	104.2	6.3	NA		195	1974
C039	8N7W27ABB	12	6.9	430	7.41	18	53	236.70	20	14.9	99.1	6	NA	I	184	1957
C040	8N7W23CBD	13	6.9	370	1.15	10	85	190.30	18	12.4	80.2	6	NA	I	200	1989
C041	8N7W21BDB	12	6.9	350	10.7	20	45	229.40	20	15.1	96	6.7	NA	I	163	1953
C042	8N7W19DCB	12	6.9	450	4.99	19	100	202.50	21	15.8	99.3	6.2	NA	I	215	1976
C043	8N8W25AO	13	6.9	350	1.84	8	75	185.40	16	12.3	79.5	5.4	NA	I	192	1956
C044	8N7W5CDD	12	6.9	460	2.15	15	98	236.70	21	15.9	106.3	4.8	NA	I	182	1973

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft	Year 5
C045	8N7W8DO	12	6.9	500	2.88	13	134	241.60	22	18.3	122.6	5.8	NA	I	156	1979
C046	8N7W3CBB	13	7	420	1.33	7	52	231.80	17	11.4	75.7	4.7	NA	I	121	
C047	8N7W11ABB	12	7	420	2.83	12	74	219.60	22	14.9	85.1	5.9	NA	I	182	1960
C048	8N6W7AAA	13	7	490	3.55	17	89	239.10	23	15.9	100.8	6	NA	I	175	1971
C049	8N8W21BBBB	12	6.7	400	5.36	27	68	187.90	15	12.6	82.1	6.9	NA	I		
C050	8N8W15CO	12	6.7	800	8.48	14	8	287.90	24	17.7	110.6	8.2	NA	I	195	1972
C051	7N7W3ABB	13	6.9	600	9.95	23	59	290.40	33	15.5	109.2	10.9	NA	I	165	1953
C052	8N6W19CO	13	6.9	360	1.14	14	62	190.30	19	10.6	65.7	6.6	NA	I	195	1986
C053	7N5W17AO	13	7.2	400	1.64	13	51	222.00	19	9.9	72.9	4.8	NA	I	220	1957
C054	7N5W19CB	12	7.2	360	0.17	.15	37	224.50	25	9.6	63.3	4.3	NA	I	187	1976
C055	7N6W28AO	12	7	625	8.82	37	177	268.40	53	17.9	132.2	8.6	NA	I	132	1955
C056	7N5W14CO	12	7.3	420	1.69	20	54	248.90	28	10.8	75.3	4.8	NA	I		
C057	7N5W1DO	12	7.1	370	2.91	18	28	236.70	21	10.4	69.4	6.1	NA	I	175	1956
C058	8N5W29CO	12	7	360	0.81	20	39	219.60	18	10.3	69.2	5.5	NA	I	188	1976
C059	8N5W32BDC	12	7.1	360	0.82	19	45	239.10	19	12.4	75.6	4.9	NA	I	195	1975
C060	8N5W19BBD	12	7.1	460	0.54	23	57	219.60	19	12.4	86	5.9	NA	I	198	1965
C061	8N6W22BO	12	7.1	460	6.45	22	40	258.60	19	13.1	93.7	6.7	NA	I	190	1974
C062	7N6W5AAC	12	7	420	2.29	116	56	224.50	21	11.2	77.5	6.9	NA	I	196	1976
C063	7N6W5ABB	13	7	420	4.68		35	NA		10.5	79.4	7.2	NA	D		
C064	7N7W5BDC	12	7	600	2.74	13	124	253.80	27	14	103.8	8.5	NA	I	212	1975
C065	7N7W5AO	12	7.1	550	3.23	16	105	244.00	25	14.2	100	9.2	NA	I		
F001	8N[illegible]18AO	11	7	410	6.18	17.3	61.12	212.75	25	11	68.4	6	NA	I	230	1976
F002	8N2[illegible]0DB	11	7.1	500	5.93	19.3	90.1	243.72	29.5	14.2	82.9	5.4	NA	I	287	1964
F003	8N3W12AO	11	7.2	370	4.24	12.5	37.3-A	229.45	24.3	9.8	60	5	NA	I	280	1976
F004	8N3W24CO	11	7	450	5.48	16	78.7	235.79	29.2	11.9	75.4	5.7	NA	I	248	1968
F005	8N3W25BA	11.5	6.9	700	15.1	27.5	140	232.14	34.2	17	100-A	7.8	0.200*	I	260	1971
F006	8N3W26AO	12	7.1	700	11.2	21.2	188	254.20	39.6	18.8	111.9	5.6	NA	I	248	1966
F007	8N2W20CBD	12	6.9	800	15.4	20.3	196-A	263.10	42.9	20.2	121.7	5	NA	I	273	1956
F008	8N2W23BCA	12	7.2	725	3.83	13.1	201	297.48	37.9	21.1	118.6	7	NA	I	270	1958
F009	8N2W23AO	11	7	1250	18.1-A	18.1	599-A	342.84	83.2	39.9	232.3A	9	NA	I	260	1957
F010	8N2W9BO	11	6.9	600	13	17.6A	186-A	185.93	33.6-A	17.6	96.1A	9.4-A	NA	I	300	1968
F011	0N1W5DDB	11	6.9	410	3.84	13	50.7	246.77	25.5	12	66.8	4.8	NA	I	240	1968
F012	0N1W15DB	11	6.9	700	3.98	9.02	186	292.97	35.8	21.2	110	7.4	NA	I	268	1967

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
F013	8N3W23AC	11	7	500	8.94	18.1	74.6	242.74	26.9	13	82	6.5	NA	I	228	1978
F014	8N3W3CO	12	7.5	350	0.02	10.9	32.8-A	230.06	24.3	9.2	51.8	5.3	NA	I	177	1982
F015	8N4W9BB	11	7.3	500	3.24	8.99	20.1	343.94	27.3	11.6	82.4	4.6	NA	I	131	1953
F016	8N4W19ACC	10	6.9	450	1.74-A	18.2-A	25.5	312.12	26	11.7	76.9	5.6	NA	I	60	
F017	8N1W23DCA	11	6.9	500	2.02	10.1	102	294.07	20.8	18.2	93.2	5.4	NA	I	247	1976
F018	8N1W29DAC	11	6.9	700	4.67-A	9.9	215-A	281.64	36.2	21.6	120.7	5.2	NA	I	288	1957
F019	7N1W17DBC	11	7.3	550	6.43	11.7	114	242.62	39.1	21.6	80.2	4.6	NA	I	299	1977
F020	6N1W15BBD	11	7	600	2.33-A	13.2	79.6-A	370.27	27.3	14	99.9	6	NA		162	1981
F021	6N2W11BB	11	6.8	480	.25-A	15.7-A	89.5	252.74	28.6	11.9	80.2	4.3	NA	I	221	1974
F022	6N2W23BBD	11	7.1	390	.02-K	12.7	64.3	221.65	25.0-A	10.6-A	60.5-A	3.6-A	NA	I	211	1954
F023	6N2W25AOAC	10	6.9	1000	7.11	8.91	384	354.30	50.3	30	196.8	13	NA	I	90	1957
F024	6N2W33DCD	11	7	380	.0.1	14.2	56.3	218.97	24.5	9.8-A	57.9	4.2	NA	I	207	1987
F025	6N3W25ADB	11	7	450	0.12	19.1	105	212.38	28.7	11.5	72	5.9-A	NA	I	230	1989
F026	7N3W1AO	11	7.3	950	10.9	19.1	376	300.90	49.4	25.2	174.8	7.4	NA	I	260	1976
F027	7N3W23BBD	11	7.5	360	0.21	16.3-A	56.4	198.73	21.7	10	57.5	5.2-A	NA	I	241	1969
F028	7N3W15DO	11	7.7	350	0.1	15	39.5	209.70	21.2	10	55.2	4.9	NA	I	238	1984
F029	6N4W11CO	11	7.4	700	11.9	29.8	156	228.36	49	17.2	104.9	7	K*	I	160	1967
F030	6N4W15ADD	11	7.1	600	8.89	21.4	125	218.70	32.8	14.6	93.8-A	6	NA	I	182	1957
F031	6N4W23BBC	11	7.5	500	4.41	22.1	80.6-A	224.45	36.1	11.3	73.9	6	NA	I		1948
F032	6N4W31ADB	11	7.3	350	2.09	19.5	40.1	180.56	25.4-A	7.5	51.8	6.8	NA	I	171	1956
F033	6N4W29BAB	11.5	7.7	550	6.68-A	18.2	40.3-A	261.88	45.5	8.9	62.8	7.7-A	NA	I	200	1967
F034	8N4W22CBA	13		400	2.55	11.3	18.5	263.96	21.6	11	63.1	4.9	NA	I	133	1974
F035	7N4W11DDB	13	7	395	2.83	15.6	57.4	202.02	22.9	10.6	63.8	7.6	NA	I	201	1955
F036	7N3W27BCC	13	7.1	360	0.83	16.3	3.61	207.51	20.6-A	10	57.3-A	4.8	NA	I	247	1974
F037	7N3W21DBD	13	7.1	340	0.15	15.2	27	206.17	19.8	9.2	53.7	5.2	NA	I	230	1957
F038	7N3W29BAA	13.5	7.2	340	0.02	15.3	30.8	209.21	18.9	9.8	56.2	5.2	NA	I	260	1977
F039	7N4W27AAA	13	7.4	500	0.03	15.4	98.7-A	262.98	33.3	15	80.3	4.2-A	NA	I	230	1988
F040	7N4W29AAD	13	7.2	525	1.09	18.3	109	288.22	29	16.2	103.7	4.4	NA	I	185	1969
F041	7N4W19BBD	13	7.1	370	0.06	19.3	35.7	218.48	25.4	9.4	56	3.9	NA	I	221	1974
F042	8N4W32CAD	13	7	410	3.45	17.2	29.7-A	246.89	29.1	10.1	62.6	5.4	NA	I	206	1957
F043	7N4W5CCD	12.5	7	470	4.78	18.2	38.6	266.52	41.8	11.3	66.3	6.4	NA	I	220	1966
F044	8N4W5BAD	13	7.1	480	3.33-A	9.13	23.7	340.89	22.9-A	13.8-A	92.9-A	4.9	NA	I	143	1957
F045	8N2W5AAB	13	7.3	410	1.56	16.1	47.6-A	236.65	29.6	10.4	66.3	6.1-A	NA	I	320	1970
F046	9N2W32CDD	13	7.2	400	0.15	14.7	50.6	235.02	26	10.2	67	5.9	NA	I		

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
F047	8N2W35BCB	14	7.1	525	2.51	11.7	148-A	261.76	27.8	18	106.6	5.9	NA	I	290	1973
F048	7N1W7DAC	13	7.4	575	2.81	13.3	188	240.67	34.8-A	18.4	112.8	4.7	NA	I	268	1976
F049	8N1W33BBC	13	7	750	2.66	8.59	275	284.20	40.4	23.2	148.8	6.2	NA	I	302	1967
F050	7N2W15BAC	13	7.2	415	2.46	12.7	69.7	211.90	29.5	10.5	67.9	4.6	NA	I		1956
F051	7N2W23BBD	12	7.2	320	1.17	9.4	28.4-A	207.14	25.2	8.4	52.2	4	NA	I	277	1979
F052	7N2W19AAC	12	7.1	470	3.79	16.6	86.5	225.80	34.6	11.8	80.2-A	6	NA	I		1954
F053	7N2W29AAC	12	7.2	330	2.36	11.4	29.5	199.83	22.5	8.9	55.7	4.8	NA	I	270	1974
F054	7N1W21BCD	13	7.1	460	6.01	9.01	53.9	264.57	49.8	11.4-A	66.4	4.4	NA	I	190	1956
F055	7N1W31AAB	12	7.3	368	0.59	10.6	31.6-A	245.18	31.7	10.2	59.1	3.7	NA	I	260	1976
F056	6N2W9BBA	13	7.2	450	0.46	15.7-A	86.8	231.89	30.3	11.2	80.5	5.5	NA	I	221	1956
F057	6N2W17CCA	12.5	7.2	460	0.33	18.9	77.6	232.26	30.8	12.2	80	4.8	NA	I	227	1974
F058	6N2W21BDB	12	7.2	430	0.03	14.6	64.9	219.94	25.8	10.2	69.7	4.3-A	NA	I	210	1956
F059	6N2W32BCD	13	7.2	430	0.72	17.8	74.3	213.36	31.6	10.2	71.5	6.4	NA	I		
F060	7N3W13ABC	13	6.9	600	4.09	17	166	232.50	33.3	16.4	103.6	6.2	NA	I	260	1975
F061	6N2W5AAC	11	7.2	350	2.81	12.6	41.7	206.90	26.8	9.6	55	3.8	NA	I	230	1965
F062	6N2W3CO	11	7.5	500	0.27	17.5	108	250.91	32.4	13.4	86.8	4.7	NA	I	234	1981
F063	6N1W20ABB	11	7.2	600	5.55	11	63.1	372.59	33.9	16.9	100.9	6.6	NA	I	113	1968
F064	6N2W13CO	11	7.4	375	.02-K	11.4	58.9	218.36	23.3	10.1	62	3.6	NA	I	197	1977
F065	6N2W27AB	11	7.3	370	0.47	13.3	55.1	217.26	24.4	10	62.6	3.8	NA	I	195	1956
F066	6N3W35CBA	11	7	500	5.28	18.2	135	200.07	35.2	12.5	85.8	7.5	NA	I	195	1965
F067	6N3W27AD	11	7.1	375	1.11	13.8	56	215.55	21.6	9.5	64.3	6.2	NA	I	200	1957
F068	6N3W21CA	11	7	450	1.88	16.1	98.6	212.38	28.8	12.1	76.6-A	13.1-	NA	I	244	1983
F069	6N4W13ACB	12	7	450	2.21	19-A	63.2	258.35	28.2-A	10.8-A	75.3	6.2	NA	I	230	1989
F070	8N1W17AO	12	7.5	525	5.5	15	134	268.40	28	16.9	99.1	6.5	NA	I	270	1964
F071	8N1W9DDB	13	7.3	600	4.16	19	159	268.40	32	18	97.1	6.3	NA	I	270	1970
F072	8N1W3BO	15	7.6	420	1.71	15	50	248.90	22	12	77.3	5.1	NA	I	227	1977
F073	7N1W11AO	13	7	450	2.29	18	64	256.20	22	13.2	78.4	4.3	NA	I	279	1976
F074	6N3W11AAB	12	6.8	420	1.91	20	100	214.70	29	11.5	72.2	4	NA	I	258	1968
F075	7N2W3CCD	12	7	430	0.45	18	84	234.20	22	11.8	71.6	4.4	NA	I	280	1966
F076	8N3W1BBD	12	7.1	600	0.21	18	165	280.60	35	17.8	107.5	7	NA	I	219	1957
F077	8N3W17BAA	11	6.8	390	3.14	17	35	253.80	32	8.7	65.7	6.3	NA	I	215	1989
F078	8N4W13AAD	12	6.9	440	3.93	19	23	334.30	32	10.7	77.5	4.9	NA	I	137	1959
F079	8N4W21ADD	13	7.1	490	6.1	18	26	309.90	25	13.5	90.7	5	NA	I		1955
F080	8N4W22ACC	14	7.6	440	3.84	17	25	287.90	24	10.3	75.6	4.8	NA	I	134	1965

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
F081	8N4W3AAB	12	7.2	410	1.99	13	21	312.30	22	11.5	80.5	4.1	NA	I	138	1974
F082	8N4W11ADA	12	7.1	410	2.84	20	23	297.70	24	11.9	76.7	4.8	NA	I	194	1956
F083	7N4W9AD	12	6.9	420	6.78	27	50	241.60	32	11.4	76	7.1	NA	I	221	1970
F084	8N1W19CBC	12	7.4	430	0.84	13	121	270.80	27	16.8	101.4	5.2	NA	I	276	
F085	8N1W1AC	12	7.1	430	5.64	13	58	258.60	34	13	78	4.6	NA	I	234	1972
F086	8N2W1CA	12	7.2	700	8.64	18	184	305.00	44	22.1	131.4	4.7	NA	I	270	1968
F087	8N2W20AAC	12	7.2	460	5.16	20	70	248.90	30	13	85.8	4	NA	I	273	1974
F088	8N2W33BAC	13	7	450	1.26	17	73	278.20	23	13.6	88.3	4.6	NA	I	270	1957
F089	7N2W5BDC	13	7.1	430	1.08	17	67	248.90	25	13.3	82.7	4.3	NA	I	280	1956
F090	7N2W7BCC	13	7.1	430	0.47	20	82	222.00	26	11.8	77.6	4.2	NA	I	297	1966
F091	7N3W19BO	12	7.3	380	0.68	21	57	222.00	20	10.7	73.1	5.1	NA	I	221	1974
F092	8N3W33DBB	13	7.3	400	0.4	22	30	305.00	24	10.9	73.7	4.3	NA	I	300	1984
F093	8N1W13ADC	13	7.2	480	0.58	14	83	300.10	24	15.3	95.3	4.5	NA	I	278	1989
F094	8N3W27DAA	13	6.9	650	2.05	21	45	261.10	24	11.4	79.7	4.8	NA	I	252	1969
F095	8N1W25BCA	13	7.1	420	0.41	20	65	261.10	21	15	83.5	6.2	NA	I	300	1980
F096	6N2W2ABB	13	7	480	3.86	19	61	205.00	29	13.2	84	4.7	NA	I	200	1966
F097	7N2W35DBB	13		370	0.33	11	63	207.40	24	12.6	75	4.4	NA	I	286	1978
H001	9N7W22DDD		6.7	410	3.98	14.1	57.7-A	233.11	22-A	11.5-A	70.2-A	5.6-A	NA	I		
H002	9N7W12CDD	11	7	480	4.13	17.7	81	252.62	26	14.4	83	5.6	NA	I	221	1978
H003	9N5W21CO	11	7	430	2.46-A	15.8	59.8	245.55	22.3	11.7	78.3	5.4	NA	I	219	1971
H004	9N5W19ABA	11		420	1.44-A	12.3	65.5-A	245.43	21-A	12	72.2	5.3	NA	I	182	1957
H005	9N5W7BAB	11	7	410	7.47	13.2	2.91-A	252.50	26.4-A	10.6-A	64.9-A	6.6-A	NA	I		1954
H006	11N5W32CDB	11	7.1	500	8.15	14.9	36.7	301.87	32.8	13.8	74.1	7.2	NA	I		1956
H007	9N5W35BCB	11	7.1	390	1.47	17	42.9	229.21	20.6	11.1-A	68.7-A	5.6	NA	I		1960
H008	10N7W19CBD	11		500	4.14	17.3	45.1	316.87	36.7-A	13	91.2	8.8	NA	I		1957
H009	9N8W21AO	11	7.3	500	0.45	14.8	76.8-A	311.99	30.8-A	14.8-A	98.2	6.3-A	NA	I	132	1963
H010	9N8W19CB	11	7.2	700	0.12	24.3	197	306.51	48.8	19	124	7.4	NA	I	168	1968
H011	9N7W5DDD	11	7.3	600	8.01-A	20.9	95.1	298.83	31.7	17.2	105.5	6.8	NA	I	231	1971
H012	13N5W25AAC	12	7.2	650	9.34	13	74.7	377.46	33	18.2	117	7.6-A	NA	I	140	1958
H013	13N5W33BCC	13	7.2	800	18	18.6	42.2	354.30	31.2-A	16.7	113.8	8.2	NA	I	243	1974
H014	12N5W11BCB	12	7.2	600	6.74-A	6.84	36.9	337.96	22.8	14.4	87-A	7	NA	I	155	1956
H015	12N5W23DAA	13	7	580	7.62	8.6	33.9	273.47	22.6	11.4	76	7	NA	D		
H016	12N5W23DO	12	7.1	520	6.53	8.57	34.9	343.33	29.1	12.5-A	73.9	7.4	NA	I		1953

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
H017	10N6W7AB	11	6.7	420	5.66	12.3	35.1	264.20	30.3	11.4	69.7	5.6	NA	I	236	1972
H018	11N6W29AC	10.5	7	370	7.88	9.17	24.1	231.53	10.6	11.6-A	69.8	7	NA	I	193	1955
H019	11N7W35AC	11	7	400	3.85	10.5	47.6	242.62	21.4	11.8	70.3	6.8	NA	I	190	1949
H020	10N7W3DBB	11	7.2	440	5.61	14.8	37.8	269.32	30.2	12.6	71.4	5.8	NA	I	200	1975
H021	11N6W25CC	10.5	7.2	410	3.35	13.6	23.6	272.98	20.2	11.2	76.1	6.3	NA	I	201	1957
H022	11N6W13CDA	10.5	7.1	700	13.3	23.5-A	34.6-A	409.77	30.4	16.2	127.9	8.2	NA	I	212	1975
H023	11N5W19ADB	11	7.3	500	6.33	23.1	33.4	311.38	24.5	12.5	91.8	6.3	NA	I	191	1956
H024	11N5W17DDC	12	7	460	2.91	19.3	33.6	297.61	24.7	11.6	81.1	6	NA	I	203	1967
H025	10N5W5CO	10	7.3	550	10.2-A	17	41.5-A	326.01	36.5	14.3	81.3	7.1	NA	I	160	1954
H026	10N5W1BAA	12		430	5.37	12.6	36.4	272.98	29.6	11.4	69.7	5.8	NA	I	232	1976
H027	11N5W36CC	11		600	14.6	15.3	31.-A	357.59	49.3	15.6	89	7.1	U*	I	191	1957
H028	11N5W29ABC	11		350	7.64	12.5	28.4	199.71	19.4-A	9.4-A	60.7-A	5.7-A	NA	I	169	1982
H029	11N5W15DDB	12		410	3.28	19	44.5	242.50	28.5	11.2	69.6	5.8	NA	I	195	1973
H030	11N5W9AAC	12		600	6.61	17.3	60.3	305.17	30.9	14.5	93.8	7.8	NA	I	211	1956
H031	11N5W5DDA	12		600	8.36	15.5-A	75.1-A	327.72	33.5	16.8	104.2	8.4	NA	I	184	1948
H032	11N6W1DC	12		600	9.04	10.5	62.6	319.80	32.3	15.1-A	92.5	8.2	NA	I	202	1956
H033	10N5W24BBB	11	7	460	7.04	17.9	34.02	287.73	24.8	13-A	78.6	5.9	NA	I	210	1955
H034	10N5W13CCB	11	7	470	8.54	17.1	32.9	290.41	24.9	13	80	6	NA	I	210	1956
H035	10N5W11CBD	10	7.1	410	7.44	13.1	32.9	256.28	22	12.6	70.3	6.2	NA	I		
H036	10N5W9BCD	11	7.1	460	7.19	15	35.9	290.29	33	12.2	74.4	6.4	NA	I	171	1963
H037	10N6W25BAD	11	7	460	8.17	17	33.9	272.61	26.7	12.2	74.3	6.8	NA	I	195	1952
H038	10N6W27BBB	11	7.2	360	2.32	10.7	39.3	227.87	23.3	9.6	59.8	5.8	NA	I		
H039	9N7W1ACD	11	7.2	450	3.78	15.9	62.9	268.88	27.9	13	76.2	5.9-A	NA	I	191	1958
H040	9N6W9DAA	11	7	600	8.44	20.4	46.9	330.40	29.4	15.5	92.5	6.3	NA	I	176	1944
H041	9N6W13DO	11	7	460	2.9	13.7	56.4	229.33	20.8-A	11.7	66.6	5.2	NA	I	200	1981
H042	9N5W17ADB	11	6.9	420	6.52	11.2	50.9	247.74	27.3	11.6	67.8	6.6	NA	I	180	1947
H043	10N7W17DBD	11	7.2	430	6.14-A	11	46.5	232.75	31.5	11.4	58.4	5.7	NA	I	161	1957
H044	10N7W7AO	12	7.4	420	6.14-A	11	46.5	232.75	31.5	11.4	58.4	5.7	NA	I	195	1980
H045	11N7W31DO	11	7.4	380	1.58	10.3	72	184.59	20.5	11.2	57.4	4.6	NA	I	221	1978
H046	11N8W14CDD	11	7.4	600	1.56	23.3-A	179	225.06	40.1	18.2	90.8	5.8	NA	I	221	1975
H047	11N8W13AAC	14	7.5	575	3.55	9.75	103	269.81	32.8	14.9	85.4	5.6	NA	I	192	1956
H048	11N7W15CAA	11	7.2	420	3.81	11.9	30.8-A	248.96	18	11.1	67.6	5.4	NA	I	221	1968
H049	11N7W19AO	14	7.3	425	2.33	11.5	61	214.58	20	11.2	60.2	6.2	NA	I	214	1973
H050	11N7W7DCA	12	7.4	600	3.09	10.1	94.2	284.56	31.5	14	89.4	6.1	NA	I	200	1956

#	legal	Temp	pH	cond	NO3+NO2-N	Cl	SO4	bicarb	Na	Mg	Ca	K	Atrazine	type	Depth	Year
1	2	C	s.u.	3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	4	ft	5
H051	11N8W33BCC	11	7.4	650	1.79	25.1	183	232.75	56.1	16.9	87.9	5.8	NA	I	195	1971
H052	11N8W28DCD	11	7.3	650	10.3-A	28.3	161	325.28	53.5	22.6	117.7	6.6	NA	I	186	1976
H053	10N8W15ACD	11	7.2	430	3.62	13.9	77.9	226.89	30.4	12.2	70.2	5.8	NA	I	195	1976
H054	9N5W11ABB	12	7.2	400	3.7	24	27	261.10	19	11.7	79.5	8.1	NA	I	160	1955
H055	9N7W11BO	13	7	500	4.59	24	164	234.20	51	29.9	164.4	12.6	NA	I	221	1965
H056	9N7W25ADC	13	7	410	6.89	18	43	258.60	22	12.9	82.9	6.1	NA	I	172	1965
H057	9N7W23BBD	13	7.3	600	5.66	16	96	283.00	27	16.3	96.5	7	NA	I	156	1973
H058	9N6W35ADB	12	7.5	410	1.78	16	51	268.40	24	12.4	83.7	7.3	NA	I	108	1966
H059	9N6W26DCA	12	6.9	400	1.67		57	NA		12.8	99.8	5.2	NA	I	100	1967
H060	10N5W27BO	14	7.2	400	4.18	18	31	246.40	22	9.5	70.3	5.8	NA	I	225	1988
H061	10N5W19DAA	13	7.4	490	7.83	20	40	305.00	38	12.8	80.9	7.2	NA	I		
H062	9N5W31BBD	12	7.1	430	3.28	17	62	244.00	22	11.8	74.1	6.8	NA	I	161	1972
H063	9N6W33BBA	12.5	7.1	450	3.41	23	61	268.40	24	12.9	82.2	6.7	NA	I	124	1964
H064	9N6W21BBD	12.5	7	500	2.87	25	113	239.10	26	15.1	92	6.3	NA	I	195	1982
H065	12N6W15BBD	11	7.1	675	1	16	190	292.80	38	13.7	115.9	12.2	NA	I	165	1980
H066	12N6W23BAA	13	7.2	725	6.47	10	148	378.20	44	15.3	132.6	9.6	NA	I	157	1956
H067	12N6W25BAC	14	7.3	465	3.19	11	67	297.70	24	11.9	84.3	6	NA	I	163	1973
H068	12N5W19DCC	12	7.4	525	6.85	17	90	309.90	30	13.4	101.4	7.4	NA	I	175	1975
H069	12N5W29CBA	13	7.1	525	6.9	10	69	309.90	34	11.8	89	7.2	NA	I		1948
H070	12N5W31CAB	12	7.2	600	14.34	11	93	305.00	38	13.7	98.8	7.1	NA	I	208	1957
H071	11N6W11BCC	13.5	7.2	600	13.01	11	49	348.00	41	12.8	89.6	7.7	NA	I	191	1958
H072	11N6W2BCB	13	7.1	460	4.47	16	64	285.50	27	1.5	79.5	8.9	NA	I		
H073	11N5W21ADD	12	6.9	440	4.53	23	39	280.60	27	12	89.3	6.9	NA	I	195	1979
H074	11N5W22BCA	13	7	390	1.04	23	41	246.40	25	10.3	72.4	6.5	NA	D	180	1981
H075	11N5W11DAB	12	6.8	500	8.12	13	44	331.80	36	13.4	96.1	7.8	NA	I	199	1963
H076	11N5W3ADC	12	6.8	500	9.1	18	57	300.10	40	13.5	94.4	7.9	NA	I	204	1954
H077	12N5W17AAC	12	6.8	600	7.27	10	82	397.70	37	16.7	124.7	8.6	NA	I	142	1957
H078	12N6W13ABA	13	7.1	550	2.35	11	101	309.90	33	15	162.9	13.1	NA	I	159	1957
H079	12N6W29AAD	13	7.2	600	0.78	12	149	261.10	36	13.9	102.3	6.8	NA	I	188	1965
H080	12N6W33CAB	13	6.6	520	7.77	11	62	295.20	34	11.8	94.1	8.9	NA	I		1949
H081	11N6W15AAC	12	7.1	460	6.22	22	38	280.60	30.2	11.5	84.1	6.7	NA	I		
H082	11N6W17DCB	13	7.1	525	7.05	18	27	297.70	32	12.9	91.6	6.3	NA	I	205	1956
H083	11N6W19AAC	13	7.2	390	2.26	17	23	207.40	18	9.1	62.2	5.6	NA	I	203	1970
H084	10N7W11DDC	13	7.1	420	4.51	14	35	263.50	32	10.3	70.7	6.2	NA	I	172	1955

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
H085	10N8W19BBD	12	6.9	550	3.67	21	130	275.70	49	14.7	84.3	7.5	NA	I	169	1955
H086	9N8W20CBB	12	7.1	650	0.11	25	142	302.60	40	17.1	112	6.3	NA	I	146	1964
H087	9N8W30CCD	13	7.2	850	3.49	45	273	358.20	46	21.7	164.7	10.5	NA	D		1932
H088	9N8W32DCC	12	7.1	550	6.78	22	87	312.30	31	15.6	101.7	7.4	NA	I	132	1957
H089	9N8W19ADA	12	7	700	0.21	16	171	339.20	36	18.4	124.9	6.8	NA	I	136	1960
H090	9N8W17DCA	12	7.1	500	0.87	16	97	280.60	24	13.8	100.8	6.4	NA	I	148	
H091	9N8W15CCB	12	7.1	490	0.9	19	83	300.10	27	13.3	95	6.1	NA	I	123	1975
H092	9N8W9CBB	12	7.4	575	0.4	19	154	285.50	26	17.2	107.8	6.1	NA	I	173	1949
H093	9N8W35DDD	12	6.9	390	7.31	14	38	229.40	17	10.8	73.7	6.4	NA	I	149	1983
H094	9N8W25BBC	12	7.1	525	4.25	25	64	307.40	28	13.9	102.7	5.9	NA	I	121	1968
H095	9N8W23AAC	12	7.1	700	9.38	34	74	344.00	34	18.1	117.3	6.4	NA	I	123	1963
H096	12N7W27DBA	13	7.1	600	4.37	25	150	295.20	53	16.9	104.8	7.1	NA	I		
H097	12N7W26BBA	12	7.2	600	5.43		126	NA		16.9	100.1	6.5	NA	I		
H098	12N7W25BO	13.5	7.1	900	12.1	23	283	346.50	50	26.3	173.3	9.5	NA	I		
H099	12N5W4CBB	12	7.3	600	6.35	18	59	388.00	32	15.3	117	7.2	NA	I		
H100	13N5W27ABD	12	7.2	600	1.67	23	62	339.20	33	12.6	101.6	6.5	NA	I	232	1956
H101	10N5W17ABB	13	7.4	420	4.47	18	41	239.10	32	10.2	68.3	5.6	NA	I	182	1979
H102	10N7W23BBA	12	7.1	350	3.77	16	38	219.60	23	8.5	55.8	7.8	NA	I	188	1965
H103	10N7W13BO	12		300	0.11	12	40	190.30	19	10.1	65	5.8	NA	I	247	1977
H104	10N7W24AAA	13	7.2	345	2.9	14	156	219.60	24	21.3	121.5	6.2	NA	I	182	1966
H105	12N7W34BAC	12	7.4	700	7.08	22	38	317.60	49	9.6	64	8.8	NA	I	182	1977
H106	11N7W1BBD	13	7.2	700	15.39	8	269	207.40	32	22.7	139.1	8.5	NA	I	210	1975
H107	11N5W35ADA	13	7	550	13.51	10	40	322.80	40	14.4	90.2	7.1	NA	I	161	1957
H108	11N5W31DCC	13	7	410	4.56	14	43	251.30	23	12.1	71.3	5.8	NA	I	219	1969
H109	10N5W3BAA	12	6.9	600	9.89	19	35	378.20	40	19.2	103.9	8.7	NA	I	153	1955
H110	9N5W9CAB	12	6.9	390	4.02	10	30	246.40	22	11.2	70.8	6.3	NA	I	180	1948
H111	9N6W29DCC	12	7	400	6.11	19	30	290.40	24	14.6	86.9	5.7	NA	I	150	1954
H112	10N6W31CO	12	7	410	5.5	2.3	50	273.30	26	14.1	87.1	5.4	NA	I	218	1986
H113	10N7W27CDC	12	7.1	350	2.18	11	38	224.50	23	10	61.1	5.9	NA	I		
H114	10N7W33BO	12	6.9	380	5.15	8	54	214.70	20	11.7	70.7	6.4	NA	I	186	1967
H115	10N7W35CO	13	7.1	350	1.29	10	55	197.60	22	10.1	61.9	5.2	NA	I	221	1976
H116	10N8W35CCA	12	7.1	500	0.21	13	114	253.80	30	14.9	90	6.6	NA	I	200	1957
H117	10N8W1BO	12	7.1	500	5.19	11	93	273.33	32	17.2	92.8	6	NA	I	221	1975
H118	10N8W17AAA	13	7.3	600	4.22	15	138	273.30	41	19.2	108	6.2	NA	I	179	1953

#	legal	Temp	pH	cond	NO3+NO2-N	Cl	SO4	bicarb	Na	Mg	Ca	K	Atrazine	type	Depth	Year
1	2	C	s.u.	3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	4	ft.	5
H119	11N8W32AAA	12	7.3	650	1.03	21	238	231.80	72	18.8	91.7	5.5	NA	I	156	1957
H120	11N8W35AAC	12	7.1	430	4.93	13	72	202.50	19	14.2	73	4.8	NA	I	212	1980
H121	11N8W35AAA	12	6.9	550	7.55	14	69	312.30	27	21.5	107.4	5.8	NA	I	180	1955
H122	11N8W12AAA	12	7.5	750	5.92	20	223	292.80	79	21.1	113.9	6.6	NA	I	191	
H123	11N7W17BBB	13	7.3	370	1.32	9	48	236.70	25	12.5	73.2	4.9	NA	I	225	1987
H124	11N7W29BCC	13	7.2	490	8.05	16	87	256.20	26	18.6	99.9	5.7	NA	I	236	1970
H125	11N5W27DDA	13		520	10.57	12	31	307.40	30	13.4	88.8	6.8	0.24	I	195	1967
H126	11N5W26BCC	12		390	3.78	18	35	231.80	24	9.6	69.1	5.1	NA	I	198	1968
H127	11N6W35CBC	13		405	5.52	16	40	234.20	23	10.7	66.7	6.3	NA	I	192	1965
H128	10N6W3CDC	13.5		500	8.27	28	37	324.50	39	14.4	91.6	6	NA	I	176	1947
H129	11N6W31AAO	14		390	2.7	11	44	217.20	25	10.1	67.5	4.9	NA	I	220	1966
H130	11N6W21CCB	13		350	3.75	13	23	212.30	18	9.4	65.9	4.8	NA	I	198	1957
H131	11N6W16BAB	15		355	0.05	9	33	214.70	19	8.9	69.5	5	NA	D	192	1956
H132	11N6W16BBB	14		460	5.96	12	29	297.70	29	11.4	87.1	5.9	NA	I	184	1953
H133	11N7W14DDA	14		400	4.33	14	20	248.90	15	10.8	68.5	5.3	NA	D	220	1956
H134	11N7W24BBA	13		340	2.78	14	25	207.40	15	9.3	59.6	4.5	NA	I	207	1958
H135	11N7W23AB	14		305	0.76	12	30	183.00	16	7.7	48.2	3.9	NA	D	210	1965
H136	10N7W2BB	13		500	8.82	18	36	309.90	30	14.1	83	5.6	NA	I	181	1956
H137	9N6W8CO	13		420	2.95	17	57	231.80	24	13.1	78.1	5.4	NA	I	195	1975
H138	9N6W19BC	13		500	3	22	113	234.20	26	16.2	97.7	6.3	NA	I	143	1972
H139	9N7W26DO	13		500	7.06	25	35	319.60	23	17	103	6.5	NA	I	156	1973
H140	9N7W34AO	13		430	5.64	18	49	234.20	23	12.3	79.9	5.5	NA	I		
H141	9N7W20DO	13		450	2.87	18	67	256.20	24	13.6	82.2	5.7	NA	I	208	1973
H142	9N8W11AC	13		600	5.05	25	108	358.70	46	19.2	127	6.3	.17	I	172	1964
H143	9N8W10BA	15		600	0.12	19	163	278.20	32	19	115.2	6	NA	D		1960'S
H144	9N8W9DBA				0.67	23	93	297.70	26	15.6	107.1	5.7	NA	I		1988
H145	9N8W9ABC	13		550	0.8	19	125	285.50	30	16.5	107.2	6.1	NA	I		
H146	9N8W3AAC	14		550	3.6	18	201	280.60	33	53.1	72.9	7.2	NA	I	205	1989
H147	10N8W4CD	13		600	6.02	24	163	268.40	39	20.7	113.6	6.8	NA	I	220	1966
H148	10N8W9BAC				3.37	24	190	244.00	37	19	110.5	6.4	NA	I		
H149	10N8W11ABB	13		460	4.49	16	80	253.80	25	14.6	80.8	7.7	NA	I	222	
H150	10N7W5BB	13		495	9.31	16	65	268.40	27	15.3	83.6	5	NA	I	281	1975
H151	11N7W5CCB	13		650	3.06	25	216	273.30	61	20.3	104.1	5.4	NA	I	215	1971
H152	11N7W3AO	14		800	14.98	18	317	253.80	33	29.3	162.6	7.5	NA	I	221	1975

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft	Year 5
H153	11N6W7BO	14		600	10.54	13	107	322.10	33	18.6	116.7	7.1	NA	I	222	1964
H154	11N6W10ABC	13		500	9.58	12	71	317.20	33	15.5	101.8	8.5	NA	I	192	1956
H155	12N6W27ABA	14		500	1.77	10	127	261.10	28	14.5	97.1	5.9	NA	I		
H156	12N6W11CA	14		700	5.87	12	239	275.70	33	18.8	140.2	9.3	NA	I	157	1957
H157	12N5W21CB	13		500	7.75	13	21	302.60	36	13.9	101.8	6.1	NA	I	163	1957
H158	12N5W5DA	13		525	6.58	12	49	341.60	34	14.8	112.3	7.1	NA	I	130	1989
H159	12N6W1AC	13		700	12.16	14	199	290.40	28	20.3	151.4	10.6	NA	I	170	1956
H160	13N5W29BB	13		550	7.47	14	91	295.20	44	15.9	112.8	9.8	NA	I	168	1955
H161	13N5W23CBA	14		500	3.34	13	58	319.60	42	13.3	102.3	7.9	NA	I	390	1970
H162	13N5W36DDC	13		600	12.23	15	56	373.30	24	19.5	111.6	8.58	NA	I	254	1971
H163	10N6W18ACA	13		500	9.22	15	33	317.20	33	12.9	93.6	6.8	NA	I	180	1948
H164	10N6W17CDC	13		330	1.36	13	34	209.80	1	9.1	64	6.4	NA	I	238	1973
H165	10N6W19AAD	13		500	11.19	13	37	309.90	21	0.1	95.4	7.8	NA	I	154	1954
H166	10N7W25CO	14		450	7.76	19	35	244.00	27	13.2	92.6	7.5	NA	I		
H167	10N7W25CBC	13		330	3.42	12	29	195.20	21	9	63.6	5.1	NA	D	120	1975
H168	10N6W34ABC	13		455	8.49	15	33	263.50	27	12.8	84.5	6.2	NA	I		
H169	10N6W34BBC	13		370	4.14	15	36	222.00	22	9.9	66.6	5.1	NA	I	186	1948
H170	10N6W27DDC	14		370	5.26	13	30	214.70	20	10.8	70.3	5.9	NA	I		
H171	10N5W30CBC	13		520	12.02	24	36	312.30	32	17.2	114.1	7.5	NA	I	185	1948
H172	10N5W30CDC	15		490	8.12	19	40	285.50	26	14.2	104.8	6.7	NA	D	185	1972
H173	10N5W25DDC	15		330	2.28	14	32	195.20	20	9.4	61	5.7	NA	D		1950
H174	10N5W25DO	13		420	7.58	19	25	241.60	19	12.3	83.7	4.9	NA	I		
H175	[illegible]W31CBB	13		390	5.07	15	30	234.20	21	11.5	77.5	4.3	NA	D	150	1975
P001	13N[illegible]W36DAA	11	7	500	8.15	8.3	64.9	291.02	26.6	15	82.5	7.4	NA	I	240	1987
P002	13N3W1BAD	11	7.1	550	4.51	9.11	40.3	369.91	40.6	16	84	6.8	NA	I	260	[illegible]
P003	14N3W26ADB	11	7	650	13.4	8.9	44.8	405.26	46	16.4	104.6	8.5	NA	I	232	[illegible]
P004	14N3W26	11	7	800	25	20.7	41	452.20	51.6	21.6	128.6	12.1	NA	D	120	1981
P005	14N3W23ABB	10	7.1	600	7.83	7.22	85.9-A	364.54	45.5	17.2	97.7	10.7-	NA	I	211	1974
P006	14N3W12BBC	11	7.3	700	9.8	8.13	74.3	437.45	42	23.5	113.8	8	NA	I	235	1967
P007	14N2W7BAA	10.5	7.4	430	6.37	2.63	24.2-A	298.46	36.1	12.8	63.6	7.3	NA	I	203	1979
P008	14N2W11DDC	11	7.2	550	1.20-A	6.19	48.7	367.71	20.9	15	97.4-A	6.7	NA	I		
P009	14N2W14DDC	10	7	600	7.3	19.8-A	48.3	408.43	23.6-A	20.8	113.8	7.8	NA	I	262	1975
P010	13N3W21CAD	11	7.1	430	1.76-A	8.61	32.0-A	314.19	20.1	12.1	81	7.2	NA	I	243	1957

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
P011	13N3W16DDC	10.5	7.1	550	8.32-A	8.88	28.6	368.08	32.6	14.8	91.8	7.7	NA	I	181	1959
P012	13N3W10CDA	11	7.2	500	0.45	6.34	22.2	363.57	23.4	12.8	94.3	8	NA	I		
P013	14N4W23DAB	11	7.2	600	10.3	7.18	52.6	374.78	47-A	14.5-A	93.2-A	9.3	NA	I	200	1974
P014	14N4W23DAB	11	7.2	700	15	26-A	39.3	407.21	44.6	19.3	108.6-A	9.8	NA	D	160	
P015	14N4W26BBC	10.5	7.1	700	18.7	9.09	108	351.74	50.2	18.6	112.8	9.9	NA	I		1954
P016	13N4W10BBB	11	7.2	550	1.39	7.8	63.6	346.98	31.1	14.4	89.5	7.4	NA	I	270	1962
P017	13N4W9DAB	10.5	7.3	550	8.83-A	5.25	38.8	348.08	41.4	13.2	83.8	8	NA	I	270	1962
P018	13N2W9DBC	10.5	7	500	5.7	8.28	44.1	314.80	30.1	15.3	78.7	9.6	NA	I		1956
P019	13N2W10ABD	11	7.1	410	2.37	6.11	24.6	306.75	18.5	11.6-A	77.6	6.8	NA	I	175	1965
P020	14N2W36CDA	11	7.3	410	1.6	4.44	18.8	338.94	17.6	12	83.5	5.8-A	NA	I	304	1969
P021	13N2W1DBC	11	7.1	440	4.26	3.31	21.6	332.84	24.8	13.4	77.9	6.9	NA	I		
P022	13N2W36ABC	10	6.9	500	9.02	4.79	38.1-A	302.12	28.4-A	12.2	83.4	6.7	NA	I		
P023	13N2W26BCD	10	6.9	400	4.7	3.43	18.4	297.12	24	11.7	71.1	6.8	NA	I	231	1957
P024	13N4W36BAO	11.5	7.3	480	6.13	8.46	25.5-A	339.67	24.5	13	89	7	NA	I		1955
P025	13N4W26ADA	12	7.4	470	6.4	5.82	57.2	302.61	25.5	13.-A	87.8	7.7-A	NA	I	198	1954
P026	13N4W35CA	12	7.1	460	0.33	13.3	41.2	306.02	15.4	12.8	86.3	6.6	NA	I	208	1976
P027	13N4W20CCD	11	7.1	600	22.4-A	14.1	34.8-A	339.91	60	13.3	88.5-A	6.8	NA	I	138	1954
P028	13N4W29CB	12	6.9	500	8.07	5.24	39.7	355.27	32.3	15.8	90.5	8.1	NA	I	325	1976
P029	13N4W29BB	12	6.9	485	5.52-A	8.97	23.1	338.08	30.2	12.9	83.7	6.2	NA	D	170	1956
P030	13N4W7ABB	13	6.9	575	2.93	11.1	67.6	348.94	31.5	15.4	97.9	7	NA	I		
P031	13N4W16DA	11.5	6.9	500	8.79	7.69	26.1-A	324.43	32.4	11.8	86.2	8.1	NA	I	247	1958
P032	13n3w7CA	12	7.3	600	5.8	6.77	107	336.87	37.3	14.8	107.8	9.2-A	NA	I	235	1956
P033	13N3W5BC	11.5	7.2	575	7.38	5.71	34.8	419.04	52.9	12.2	95.9	8.2	NA	I		
P034	14N3W34CC	11	7	825	1.46-A	7.64	245	436.47	40.7	21.9	176.4	9.3	NA	I		
P035	13N3W23BC	11.5	7.2	500	2.34	13.7-A	32.4-A	344.06	22.8	13.6	90.4	7.4	NA	I	240	1971
P036	13N2W32AB	11	6.9	500	6.48	6.81	27.9	354.30	23.5	14.1	95.1	7.5	NA	I		
P037	13N1W22CO	12		470	5.16	7	12	361.10	30	12	87.5	5	NA	I	280	1957
P038	13N1W28AO	12		480	5.3	7	31	329.40	30	12.7	83.7	5.9	NA	I	380	1967
P039	13N1W32ABC	12		500	8.49	9	15	358.70	33	13.5	89.3	8.5	NA	I	190	1959
P040	13N2W27BAD	12		340	2.9	5	18	236.70	18	9.5	60.9	6.1	NA	I	170	1962
P041	14N1W35DO	12.5		490	0.5	8	39	363.60	29	14.7	84.4	5.3	NA	I	279	1975
P042	14N1W1BBD	13		450	3.68	4	25	344.00	35	11.8	74.2	6.5	NA	I	280	1969
P043	15N1W34AO	13		430	2.06	9	22	317.20	18	12.7	81	6.7	NA	I		
P044	15N1W27CBD	12		470	2.73	8	28	319.60	28	14.1	79	7.9	NA	I	260	1958

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
P045	13N3W12CAD	12.5		550	4.44	12	48	380.60	1.57	14.6	99.7	7	NA	I		1954
P046	14N2W29DD	12		600	4.95	12	51	409.90	34	15.9	111.7	6	NA	I	239	1958
P047	14N3W13DA	11		625	13.67	18	48	409.90	50	18.9	100.4	8.5	<DL	I		
P048	15N2W33CD	12		450	2.81	12	36	309.90	17	12.8	82.2	6.7	NA	I	212	1976
P049	15N2W31DA	11.5		490	6.19	11	36	344.00	30	15	88.2	7	NA	I	194	1969
P050	14N1W5BC	12		440	4.84	8	25	258.20	21	10.6	67.5	5.5	NA	I	260	1968
P051	14N1W14BB	12		500	8.56	10	38	348.90	35	13.6	89.8	5.5	NA	I	275	1973
P052	14N1W8DDB	12		480	0.26	10	43	312.30	15	14.1	95.8	8.1	NA	I	269	1958
P053	13N1W16AD	12.5		440	0.37	11	0	309.90	0	0.1	0.1	0.1	NA		300	1975
P054	13N2W29ACC	12		410	2.31	8	20	309.90	22	11.3	80.5	6.1	NA	I	234	1976
P055	13N2W34ACA	11.5		445	3.86	10	20	348.90	28	12.3	87.3	6.3	NA	I	185	1955
P056	13N2W24ACA	12.5		500	7.25	9	66	312.30	28	13.9	94.8	6.7	NA	I	198	1975
P057	13N1W20AAC	13		440	2.17	8	24	319.60	24	11.3	80.6	6	NA	I	270	1964
P058	13N1W20AAB	13		450	3.06	11	32	327.00	34	12.8	77.3	5.8	NA	D		
P059	14N2W9DDB	13		520	1.98	11	42	397.70	21	16.5	108.6	6.4	NA	I	248	1989
P060	15N2W35AD	12		425	6.43	11	20	309.90	25	12.9	74.9	6.2	NA	I		1957
P061	14N1W6ACD	13		315	5.51	11	15	219.60	18	8.7	50.9	6.3	NA	I	280	1967
P062	14N1W9BCC	13		500	1.14	12	49	348.90	22	13.9	98.1	8.1	NA	I	278	1972
Y001	10N4W22BCB	11	7.1	380	3.73	11.3	32.6	238.96	18.5	11.6	63.9	6.8	NA	I	189	1958
Y002	10N4W15CB	11	7.2	525	9	12.5	32.4	328.43	34.0-A	14.5	82.7	7	NA	I	192	1955
Y003	11N2W32BAB	11	7	470	4.4	10.1	39.2	307.60	28.6	13	76	6.6	K*	I	247	1976
Y004	11N2W34DCB	11	7.1	600	12-A	11.1	30.3	402.82	66.9	17.4	81.3	8.2	NA	I	248	1957
Y005	11N1W28AD	10	7.1	430	11.3	7.99	38.5-A	241.40	23.9	12	70	6.6	NA	I	304	1969
Y006	11N1W25BCD	11	7.2	390	4.28	6.3	24.3	264.93	19.7	10.5	66.7	5.5	NA	I		1955
Y007	10N1W14ACA	11	7.1	420	6.33	11.2	64.8-A	207.75	24.6	13.2	61.1	8.6	NA	I	163	1963
Y008	10N1W21ACB	10	7	350	4.98	12.1	23.4	211.41	31.1-A	10.5-A	44.2-A	6.9-A	NA	I	225	1977
Y009	10N1W25BAB	11.5	7.5	450	0.11-A	8.53-A	34.6	325.04	17.9	13.6	82.4	5.9	NA	I	170	1975
Y010	9N1W14BDD	11	7.3	480	3.41	10.1	85.5	252.98	31.5	13.8-A	76	5.7	NA	I	266	1971
Y011	9N1W17CDD	12	7.2	370	1.86-A	18.5	38.1	212.26	23.1	10	56.6	5.6	NA	I	300	1977
Y012	9N1W20BDD	12	7.4	390	1.48	18.6	43.2	221.28	24.4-A	10.2	59.2	5.4	NA	I		
Y013	9N1W32BDA	11	7.2	390	4.11	13.1	100	236.65	29.8	15.5	79.3	6.2	NA	I	225	1964
Y014	10N3W19CCA	11	7.3	450	6.13	8.93	25.4	305.65	24.8	13.8	81.4	6	NA	I		
Y015	10N3W31CCA	11	7.2	460	6.62	14.2-A	29.3	298.95	24.5	13.2	78.7	6	NA	I	169	1955

#	legal	Temp	pH	cond	NO3+NO2-N	Cl	SO4	bicarb	Na	Mg	Ca	K	Atrazine	type	Depth	Year
1	2	C	s.u.	3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	4	ft.	5
Y016	9N4W1BCB	12	7.2	350	1.72	14.7	30.3	213.97	21.5	9.3	58.6	4.8	U*	D	150	1973
Y017	9N4W1BBB	11	7.2	420	4.3	17.8-A	27	255.54	22.1	11.5	73.1	5.5	NA	I	180	1959
Y018	9N4W3BO	11	7.3	420	3.21	14.3	27.1	271.88	24.8	12.2	71.9	5.8	NA	I	220	1977
Y019	9N4W30BO	10	7.3	600	5.61	17.8	104	252.98	40.4	16.7-A	84.2	8	NA	I	122	1980
Y020	9N4W28AO	11	7.5	370	1.6	15.3	29.9	227.02	22.3	10.3	60.9	5.9	NA	I	130	1983
Y021	9N2W1CCA	11	7.1	360	1.99	9.35	19.2	246.40	22.3	9.8	61.5	5.7	NA	I	205	1964
Y022	9N2W3CA	11	7.2	390	4.83	10.7	21.1	258.10	21.2	11.2	69.3	5.4	NA	I	180	1964
Y023	9N2W26CD	11	7	310	4.33	5.44	22	182.51	22.1	8.6	43.7	10.1	NA	I	260	1968
Y024	10N4W31AC	11	7.2	470	7.11	19.6-A	28.4	281.51	21.2	14	88	7.1	NA	I	208	1977
Y025	9N2W11AC	11	7.5	380	3	10.8	22	242.26	25.9	10.3	62.2	5	NA	I	122	1956
Y026	10N3W3CAC	11	6.9	410	4.38	9.01	23	266.02	27.7	12.5	65.6	6	NA	I	123	1950
Y027	11N4W25ADB	11	7.2	600	16.4-A	12.4	30.3	347.59	60.1	15.7	77.4	7.4	0.182*	I	102	1961
Y028	11N3W30BBB	11.5	7	600	13.2	15.5-A	34.7	313.09	50.3	15	72	7.2	NA	I	110	1966
Y029	11N3W20BCD	11.5	7	550	5.51	13.1	78.6	286.76	32.2	18	74	8.1	NA	I	248	1957
Y030	11N4W13AAB	11.5	7	550	5.43	12	30.9-A	334.67	33.6	13.8	83.4-A	6.2	NA	I	138	1955
Y031	11N4W8ADD	10	6.9	550	11.1	10.5	31.7	325.53	35.4	14.8	82.5	6.9	NA	I	150	1954
Y032	11N4W9BBC	11	7.1	550	9.96	13.9	42.4	332.72	36.7	14.8	85.7	7.6	NA	I	160	1958
Y033	11N4W3DDB	11	7	430	6.75	10.1	29	274.44	24	12-A	64.5	6.4	NA	I	186	1957
Y034	12N4W35BCD	12	7	420	2.89	10.1	44.2	254.45	23.4	10	67.3	7.8	NA	I	250	1971
Y035	12N3W15ABD	11	7	470	6.07	4.67	26.1	334.79	29	13.2	79.7	6.4-A	NA	I	152	1965
Y036	12N3W8CCD	11	7.2	550	3.92	8.21	35.9	362.22	35.7-A	13.4-A	83.3	8.3-A	NA	I	155	1958
Y037	10N1W7DDC	11	6.9	400	4.6	14.6	29.9	246.77	33.3	12.8	57.3	7.1	NA	I	245	1976
Y038	10N1W7BBD	11	7	600	12.1-A	9.62	108	293.58	56	19.5	84.9	7.8	NA	I	94	1955
Y039	11N2W14CCD	13	7.2	600	8.49-A	9.17-A	29.1	287.73	25.4	14.4	76.5	6.6	NA	I	325	1981
Y040	12N2W35CCA	10	7.1	575	NA	15.2	77.1-A	327.72	36	18.4	94	7.5	NA	I	121	1976
Y041	11N2W6BDC	10	7	450	5.03	9.53	30.8	298.83	25.7	13.4	81.2	6.4	NA	I	95	1957
Y042	11N3W1CDC	13	7	500	5.2	11.6	26.4	318.82	26.9	13.9	81.6	6.2	NA	D		
Y043	11N3W1CCB	13	7.1	600	8.44	11.1	27.4	318.94	30.5	13.8	83	6-A	NA	I	212	1956
Y044	11N3W11ACD	11	7.1	550	7.53	10.2	60.9-A	291.88	37.5	14.8-A	78.9	7	NA	I		
Y045	12N3W23BAC	11	6.9	700	16.1-A	9.94	131	271.64	35.2	17.6	106.1	8.4	K*	I	162	1984
Y046	11N3W3DDAB	11	7.2	440	4.5	10.1	27.3	301.39	22.5	12.8	77.2-A	6	NA	I	247	1976
Y047	11N2W29ABC	11	7.2	380	0.79	8.1	39.6	258.96	24.4-A	10.7	64.6	5.4	NA	I		
Y048	11N2W26BAA	11	7.2	420	2.12	7.25	43.7	277.49	28.1	13	67.6	6	NA	I	287	1957
Y049	11N2W24CBD	12	7.3	410	0.5	10.3	46.1-A	261.40	21.4	13.7	66.1	6.4	NA	I	334	1974

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft	Year 5
Y050	10N2W3DDB	11	7.4	360	0.1	9.55	33.4	236.89	19.9	10.8	58.5	5.1	NA	I	325	1989
Y051	11N2W20DCC	13	7.2	650	2.4	7.99	59.8	315.77	36.3	13.2	77.4	6.7	NA	I	260	1987
Y052	12N2W14CAC	13	7	650	4.26	5.6	23.7	290.54	21.4	11.1	71.9	6.7	NA	I	197	1957
Y053	12N2W24DBC	13	7	650	3.6	8.9	28.4	291.15	27.1	11.7	71.2	5.8	NA	I	205	1956
Y054	12N2W12AAC	13	7	675	3.83	6.89	27.9	305.53	20.2	13.5	77.3	6.7	NA	I		
Y055	12N2W1BBD	13	6.9	675	2.69	4.56	23	276.27	19.9-A	11.3	68.8	6.2	NA	I	281	1956
Y056	12N3W1DAA	30		1100	0.04	42.1	22.5	299.80	21.3	13.4	38.3	81.6	NA	I	200	1964
Y057	12N2W19BAC	12	6.9	650	6.85	9.4-A	29.5	324.67	29.9	14	88.5	6.2	NA	I	165	1955
Y058	11N3W2BAD	12	6.9	580	7.7	9.66	44.2	263.71	18.4	13.2	79.5	6.8	U*	I		
Y059	11N2W8CAD	12	7.4	490	0.13	8.93	36.2	238.23	18.5	9.2	62.2	5	NA	I	273	1976
Y060	11N2W16DCA	12	7.4	520	0.1	9.58	39.3	242.62	19	10.6	64.5	5.5	NA	I	312	1977
Y061	10N2W8ABD	11	6.8	850	8.05	37.3	136	318.70	44.3	24.2	109.6	9.3	NA	I	262	1978
Y062	10N2W5AAC	12	7.1	800	11.7	19.9	44.7	343.33	46.8	17.5	89.1	8.2	NA	I	222	1956
Y063	11N2W25CCD	11	7.1	650	8.98-A	8.33	38.5	293.83	28.2-A	13.4	77	6.5	NA	I	215	1967
Y064	11N2W18BBB	12	7.2	650	5.58	8.33	23.4	356.01	38.2	13.7	79	6.4	NA	I	230	1957
Y065	12N3W11BDC	12	7.3	800	7	6.05	31.9	380.51	29.1	16	95.4	7	NA	I	154	1962
Y066	12N3W6BDB	12	7.5	580	1.16	11	45.-A	286.27	24	13.4	75.8	7	NA	I	210	1980
Y067	12N4W12BBD	12	7.3	700	8.6	7.8	34.7	363.69	39.2-A	14.8-A	89.2-A	6.8-A	NA	I	165	1955
Y068	12N4W14BBA	12	7.3	650	4.9	12.1	35	334.30	27.3	13.6	87.5	6.1	NA	I	250	1967
Y069	12N4W8DDC	12	7.3	600	6.22-A	12-A	41.8	315.53	27	13.8	88.4	6.5	NA	I	195	1968
Y070	12N4W6CCB	12	7.3	560	7.44	6.63	33.8	259.6[illegible]	18.9	12.6	71.4	7	NA	I	208	1970
Y071	10N2W30DDA	11	7	700	9.4-A	13.2	45.4	290.[illegible]	28	14	88.6	8.4	NA	I	160	1946
Y072	1[illegible]N2W27BBD	12	7		6.33	13.2	29.8-A	257.[illegible]	22.9	12	68.8	7	NA	I	225	1976
Y073	1[illegible]2W25BAC	12.5	7		8.27	9.22	20.3	282.7[illegible]	32.8	12.5	65.1	7	NA	I		
Y074	10N1W19D0	12	7		3.69	7.18	19	264.93	27.9	11	58.6	6.7	NA	I	299	1987
Y075	10N1W22BBA	12	6.8	530	7.86	14.3	23.-A	232.87	28.8	13.4	54.6	8.6	NA	I	165	1961
Y076	9N1W6AO	12.5	7	550	4.88	7.54	19.3	257.86	26.3	10.4	62.9	6	NA	I	221	197[illegible]
Y077	9N1W7ADC	11	6.8	560	6.32	15.6	77.3-A	198.73	26.9	12	68	7.2	NA	I	81	194[illegible]
Y078	9N1W3DBB	12	6.9	500	2.86	7.17	17.3	245.91	22.7	10.2	57.1	5.9	NA	I	158	1955
Y079	9N1W2BBC	12	6.9	430	2.66	6.75	16.7	213.73	18.9	9	44.6	5.1	NA	I	94	1965
Y080	9N1W13A0	12.5	7.4	600	2.26	17.2	55.2	263.35	21	12	77.2	5.5-A	NA	I	279	1972
Y081	9N1W36AAC	12	7	550	4.15	6.05	46.5	246.64	25.5-A	11.7	67.2-A	5.2	NA	I	243	
Y082	10N1W9ABD	11	7.1	430	7.59	9.65	26.6	298.46	33.6	12.2	69.6	5.7	NA	I		
Y083	10N1W10CBD	11	7.2	380	5.59	6.94	28.1	255.18	26.9	10.8	59.8-A	5.2	NA	I	90	1955

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
Y084	10N3W26BBA	13	7	410	8.44	16	22	273.30	23	10.1	77	6.1	NA	D		
Y085	10N4W22DAB	11	7.1	400	3.74	19	32	278.20	22	12.8	75.3	7.3	NA	I	174	1953
Y086	10N3W18CAA	10.5	7	460	6.33	13	46	287.90	21	13.1	91	6.5	NA	I	91	1957
Y087	10N4W24BAC	11	7	450	9.12	13	30	309.90	27	12.8	88.2	6.2	NA	I	151	1960
Y088	10N4W17BBC	11	7.1	360	5.68	15	49	204.90	19	10.3	65.2	6.3	NA	I	164	1974
Y089	11N3W35CBA	12	NA	525	10.09	10	28	383.10	53	15.1	80.8	7.3	NA	I	123	1958
Y090	11N3W33DBD	12	NA	500	8.5	13	33	356.20	446	14.6	85.4	7	NA	I	112	1957
Y091	11N4W36DCC	13	NA	525	14.51	16	27	348.90	58	13.7	85.7	7.2	0.447	I	116	1956
Y092	10N4W7CO	13	NA	395	3.32	18	30	270.80	24	12.1	71.6	6.4	NA	I	208	1980
Y093	10N4W19CCC	13	NA	440	5.85	20	27	302.60	24	12.9	85.4	6.3	NA	I	191	1958
Y094	11N4W20CDD	12	NA	500	10.95	20	36	314.80	44	14.8	81.1	7.8	NA	I	112	1958
Y095	11N4W18BCB	12	NA	525	10.6	20	35	329.40	31	15.5	120.5	9	U	I	201	1966
Y096	11N4W6BO	13	NA	420	3.89	11	41	280.60	26	11	75.1	8.6	NA	I	195	1979
Y097	12N4W32DC	14	NA	480	4.45	14	58	302.60	29	12.4	88.5	6.9	NA	I	222	1967
Y098	12N4W28DCD	13	NA	480	5.43	13	56	295.20	32	11.8	83	7.3	NA	I	203	1957
Y099	12N4W30BCC	13	NA	600	6.17	9	53	405.00	44	15.9	107.3	8.7	NA	I	205	1947
Y100	12N4W20BO	13	NA	430	4.27	15	34	280.60	27	10.9	73.5	6.9	NA	I	188	1971
Y101	12N4W17DO	13	NA	430	2.13	15	44	297.70	26	11.3	78.8	6.9	NA	I	260	1976
Y102	12N4W4AO	12	NA	490	6.66	114	59	302.60	20	14.1	94.4	7.7	NA	I	172	1967
Y103	12N1W7CBD	12	6.7	420	3.27	12	31	307.40	22	12.5	83.3	6.4	NA	I	282	1982
Y104	12N2W18ABB	13	6.9	500	7.66	14	30	351.40	33	13.8	93.8	9.9	NA	I	222	1963
Y105	10N1W2AAC	13	7	460	9.77	18	56	244.00	24	13.5	84.4	5.7	NA	I	305	1967
Y106	11N1W35AAC	13	7.2	420	2.79	13	31	290.40	26	11.2	75.7	5.1	NA	I	301	1967
Y107	11N1W1CCB	13	7	445	11.74	114	20	280.60	35	11.7	70.9	6.5	NA	I		
Y108	11N1W3AAC	12	6.9	380	7.11	15	20	246.40	25	11.3	63.6	6	NA	I	198	1956
Y109	12N1W26BBD	12	7.2	470	5.59	11	26	339.20	36	13.4	87.5	6.3	NA	I	241	1957
Y110	12N1W29ABD	11	6.5	350	23.87	12	33	124.40	22	11.7	49.4	8.3	NA	I	110	1972
Y111	12N1W24AAB	12	7.3	440	8.02	8	15	319.60	32	13	76.9	5.1	NA	I	255	1958
Y112	12N1W12AAA	13	7.3	460	1.8	12	26	334.30	28	11.7	89.1	5.5	NA	I		
Y113	11N4W22CCD	13	7.1	480	12.35	17	36	280.60	49	12.9	72.5	7.9	0.179	I	110	1961
Y114	11N4W16AO	13	7.1	390	1.84	20	39	236.70	23	10.4	70.1	5	NA	I	240	1979
Y115	11N4W23CDB	13	7.1	500	8.33	20	71	285.50	36	14.7	84.4	7	NA	I	112	1953
Y116	11N3W15CCB	13	7.5	430	1.23	17	52	278.20	29	11.4	79.7	5	NA	I	258	1958
Y117	10N2W22AAA	12	7	410	7	17	40	246.40	26	14.6	72.3	8	NA	I	212	1966

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
Y118	10N2W15BD	12	6.9	460	5.99	32	54	256.20	30	15.7	80.8	9.4	NA	I	178	1972
Y119	10N3W7DAO	12	7.1	550	11.58	21	41	322.10	27	17.6	105.9	8.3	NA	I	129	1972
Y120	10N3W22DDB	13	7	420	10.04	25	22	251.30	28	12.1	76	11	NA	I	154	1966
Y121	9N2W17BDC	12	6.9	410	4.76	49	7	346.50	52	18	107.6	9	NA	I	207	1972
Y122	9N2W19AAB	12	7	500	5.39	26	86	290.40	43	16.7	96.9	7.6	NA	I	70	1965
Y123	9N2W32ABC	13	7.1	600	6.04	17	187	285.50	39	20.4	116.5	7.3	NA	I	342	1964
Y124	9N2W31CBB	12	6.8	1150	10.21	31	470	309.90	98	41.6	223.4	13.6	0.156	I	180	1977
Y125	9N3W36DO	13	7.3	600	1.89	23	193	261.10	32	20.1	121.7	8.3	NA	I		
Y126	9N3W16CAD	12	7.1	420	6.74	21	31	258.60	24	13	79.2	8.6	NA	I	182	1956
Y127	9N3W20BBD	12	6.9	380	4.64	21	30	246.40	16	11.7	79.1	7.9	NA	I	223	1971
Y128	9N4W23DDB	12	7.1	450	5.51	20	39	287.90	26	13.6	87.6	7.1	NA	I	181	1948
Y129	9N4W35AO	12	7	450	2.44	20	81	270.80	26	12.8	71.6	7.9	NA	I		
Y130	9N1W22CCC	13	7	550	14.32	10	117	266.00	43	18.9	114.5	6.2	NA	I	275	1970
Y131	9N1W36CO	13	7.1	460	4.7	7	76	268.40	32	15.5	92.9	4.8	NA	I	234	1976
Y132	12N1W32CBB	13	7	450	6.03	10	55	295.20	32	15.8	92.7	6.9	NA	I	275	1965
Y133	12N1W31AAA	13	6.5	260	10.74	6	27	97.60	12	11.3	42	8.9	NA	D	98	1957
Y134	11N1W6AO	13	7.1	460	4.43	7	46	297.70	30	15.8	96.5	6.9	NA	I		
Y135	12N1W29BCD	13	6.9	625	26.23	13	94	317.20	70	26.7	104.1	11.8	NA	I	140	1956
Y136	12N1W4BDA	13	7.2	450	0.84	6	38	334.30	19	14.9	108.6	6.4	NA	I	299	1972
Y137	11N2W12CCA	12	6.9	410	7.09	7	36	268.40	29	14.7	87.7	6	NA	I	293	1970
Y138	11N3W23BBA	13	7.1	550	8.1	10	59	334.30	45	18	102	7.7	NA	I	250	1965
Y139	10N2W17DBB	13	7	460	8.4	10	31	290.40	35	14.7	89.1	7.5	NA	I	136	1962
Y140	9N2W5BO	13	7	440	6.52	12	27	297.70	33	13.7	91.3	5.6	NA	I	208	1984
Y141	9N2W15BO	12	7	800	6.61	26	294	278.20	73	28.9	146.8	10	NA	I	236	1972
Y142	9N2W21CDA	13	7.1	430	5	16	46	266.00	40	13.7	86.8	5.6	NA	I	254	1956
Y143	9N3W12CDA	12	7.1	400	4.97	16	32	261.10	25	12.7	87.6	4.7	NA	I	180	1972
Y144	9N3W26ACC	14	7.3	390	1.09	15	30	263.50	27	11.5	82	4.3	NA	I	280	1960
Y145	9N3W35BC	13	7.2	390	1.06	15	1090	222.00	22	12.8	87.2	4.4	NA	I	191	1956
Y146	9N3W33BAC	12	7.2	450	5.39	12	29	319.60	26	17.3	119	6	NA	I		
Y147	9N3W29AO	13	6.9	410	3.1	12	27	280.60	24	15	102.7	5.2	NA	I	181	1956
Y148	9N3W32CBB	13	7.4	600	9.03	13	28	378.20	32	19.9	139.8	5.4	NA	I	320	1966
Y149	9N4W25AAC	13	7.5	480	7.81	13	32	327.00	32	17.7	117.2	6.6	NA	I	200	1965
Y150	9N4W10CBB	13	7.2	490	8.59	16	34	322.10	32	18.4	124.1	5.6	NA	I	186	1953
Y151	10N3W9BAA	13	6.7	400	4.31	10	51	244.00	26	12.4	68.9	7.3	NA	I	78	1973

# 1	legal 2	Temp C	pH s.u.	cond 3	NO3+NO2-N mg/l	Cl mg/l	SO4 mg/l	bicarb mg/l	Na mg/l	Mg mg/l	Ca mg/l	K mg/l	Atrazine ug/l	type 4	Depth ft.	Year 5
Y152	10N4W10BDO	12	7	550	1.36	16	118	278.20	28	17.1	103.5	8.2	NA	I	143	1981
Y153	11N4W30AC	12	7.1	460	8.14	17	42	292.80	34	15.6	77.9	7.2	NA	I	142	1946
Y154	10N2W13DCD	12	7.2	460	9.28	8	31	309.90	48	13.3	78.6	6.6	NA	I	165	1956
Y155	10N2W13CAC	12	6.9	410	3.54	11	23	253.80	27	13.3	71.4	6.7	NA	I	173	1956
Y156	10N1W19BBC	12	7	470	9.38	11	24	309.90	42	13.2	79.5	6.3	NA	I	180	1966
Y157	10N1W25CCC	12	7.1	410	3.08	10	26	275.70	26	11.2	68.4	6	NA	I	221	1963
Y158	12N3W17DCA	12	7	550	5.54	10	28	356.20	31	12.8	91.5	8.6	NA	I	170	1968
Y159	12N3W33DBB	12	6.9	450	2.63	13	32	305.00	26	11	76.2	6.5	NA	I	178	1957
Y160	11N4W12CO	12	7.1	600	9.45	13	33	651.50	34	14.3	95.6	6.2	NA	I	160	1955
Y161	10N3W32BCB	12	7	450	6.96	10	25	297.70	26	12.4	78.5	6.8	NA		150	1969
Y162	11N1W30ABC	12	7	480	9.44	10	44	290.40	24	14.7	103.4	6.6	NA	I	290	1956
Y163	11N1W30BBA	12	7.2	550	14.31	13	45	309.90	31	17.1	107.1	7	NA	I	300	1967
Y164	12N2W9AC	12	7	450	6.39	7	31	319.60	34	14.8	95.3	6.8	NA	I	237	1964

NOTES:

1 Sample Number
- A - Adams Co.
- C - Clay Co.
- F - Fillmore Co.
- H - Hamilton Co.
- P - Polk Co.
- Y - York Co.

2 Legal Location - Township, Range, Section, 1/4 Section

3 umhos/cm

4 Well Type - I = Irrigation, D = Domestic

5 Year Well Registered

bicarb = HCO3

NA Not Analyzed

U Analyzed, but not detected

K Detected, but not quantified

A Average of two trials

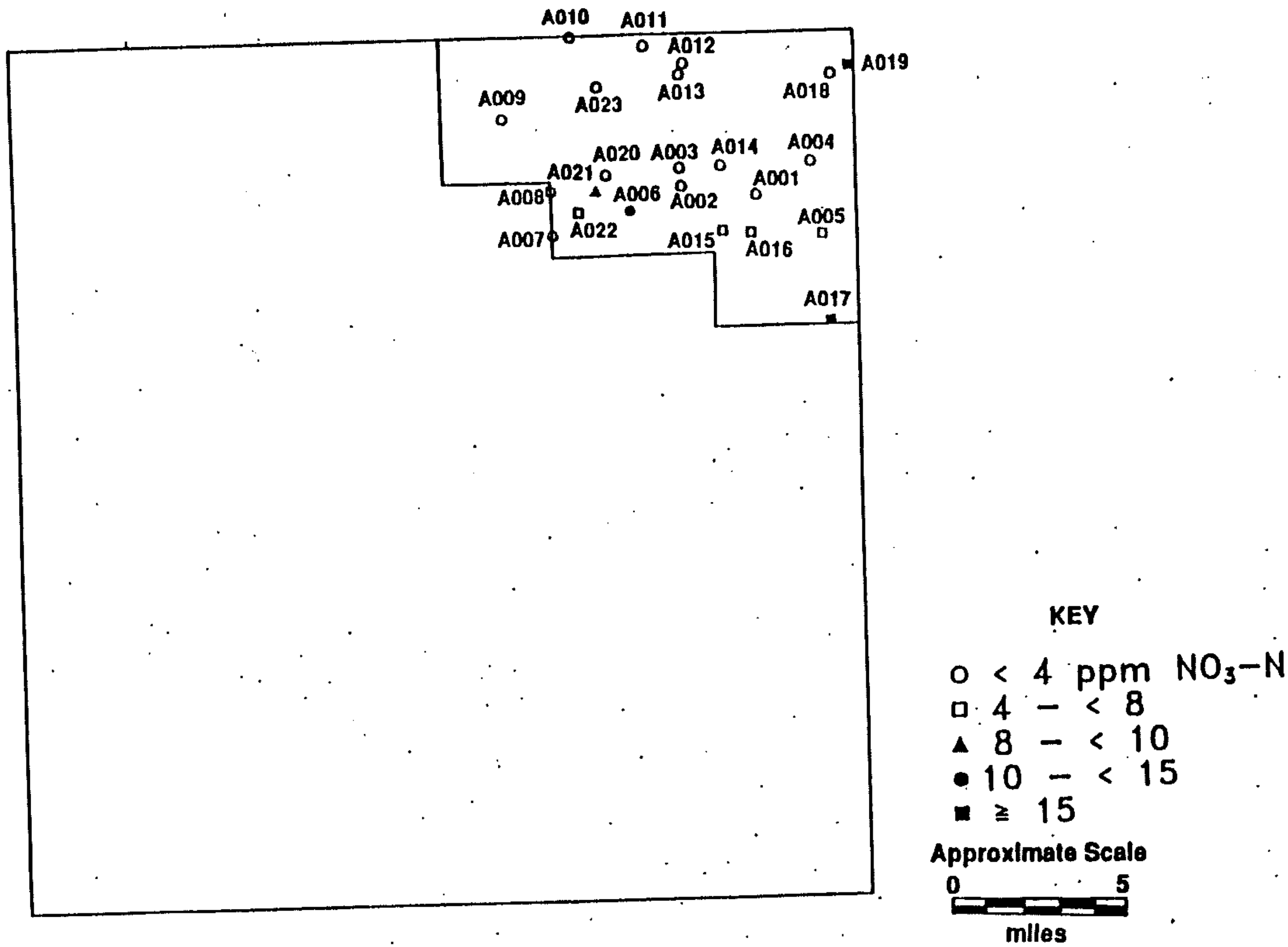
<DL less than Detection Level

* other pesticides analysed for, but not detecetd:

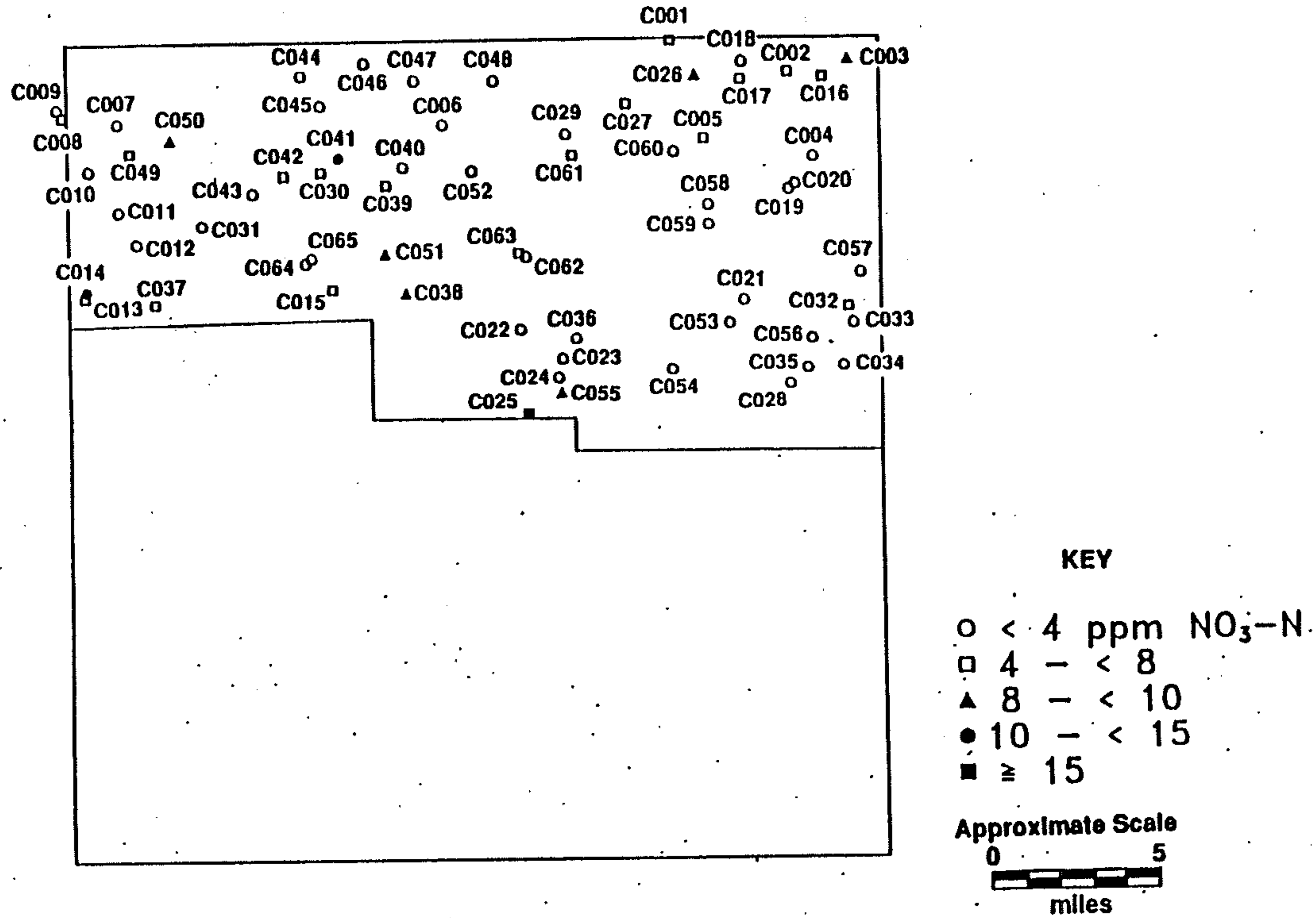
Eptam (EPTC)	Fonofos (Dyfonate)
Sutan (Butylate)	Chlorpyrifos (Lorsban)
Treflan (Trifluralin)	Cyanazine (Bladex)
Sencor (Metribuzan)	Metolachlor (Dual)
Propachlor (Ramrod)	Prometon
Furadan (Carbofuran)	Simazine
Alachlor (Lasso)	Cyprazine
Terbufos (Counter)	Ametryn
Sevin	Propazine

Appendix F. Approximate Sampling Locations by County

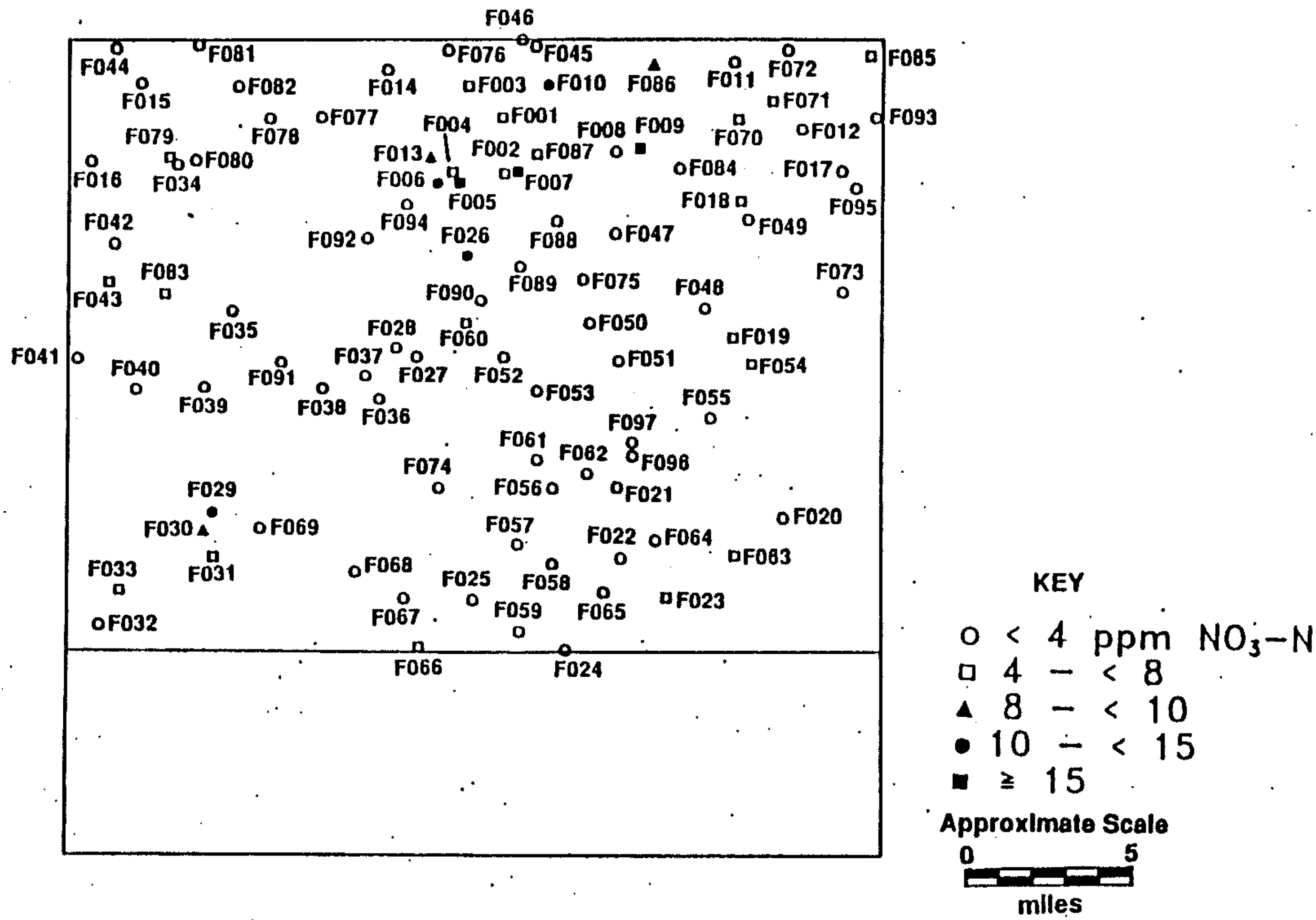
Adams County Sampling Locations



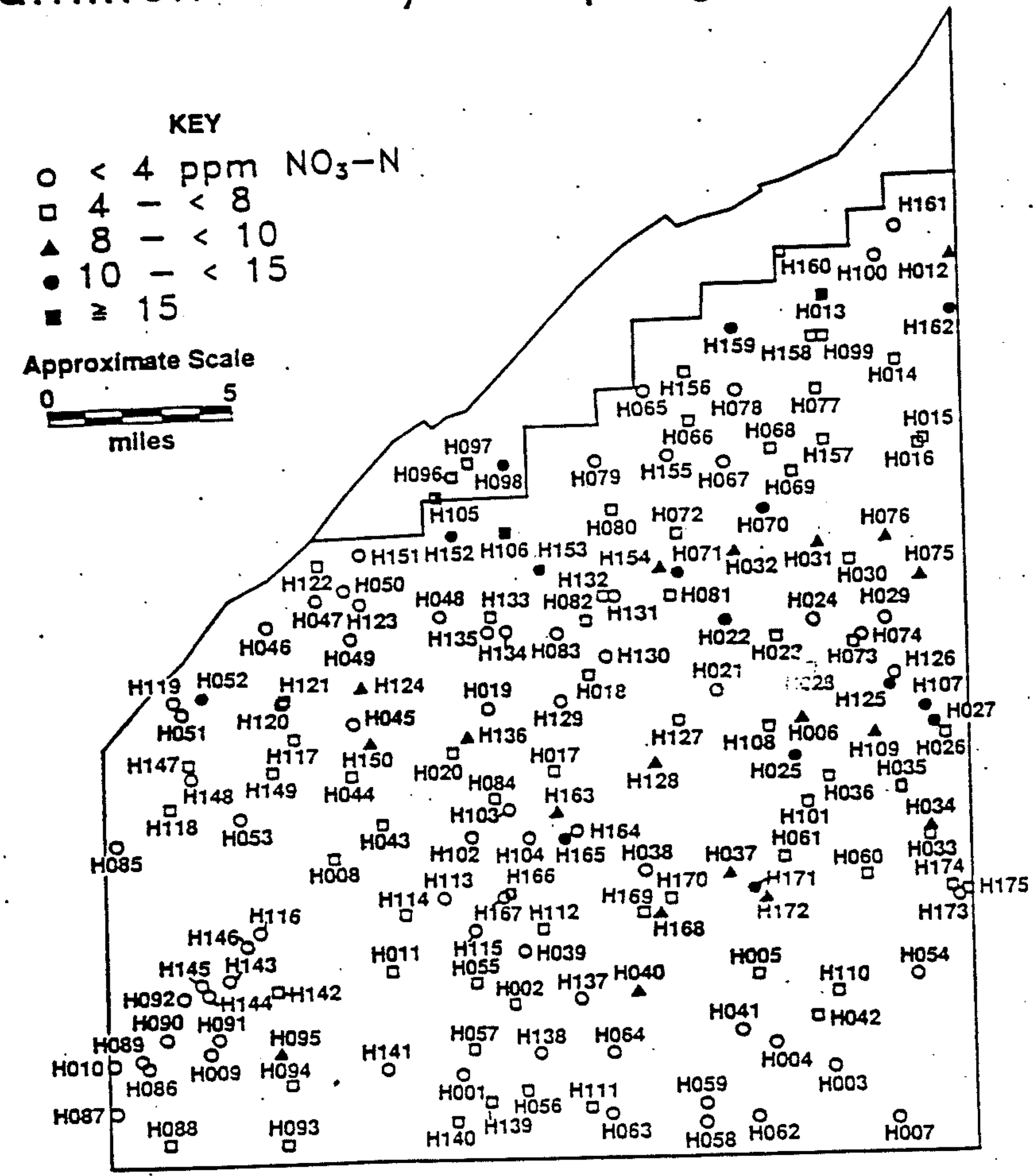
Clay County Sampling Locations



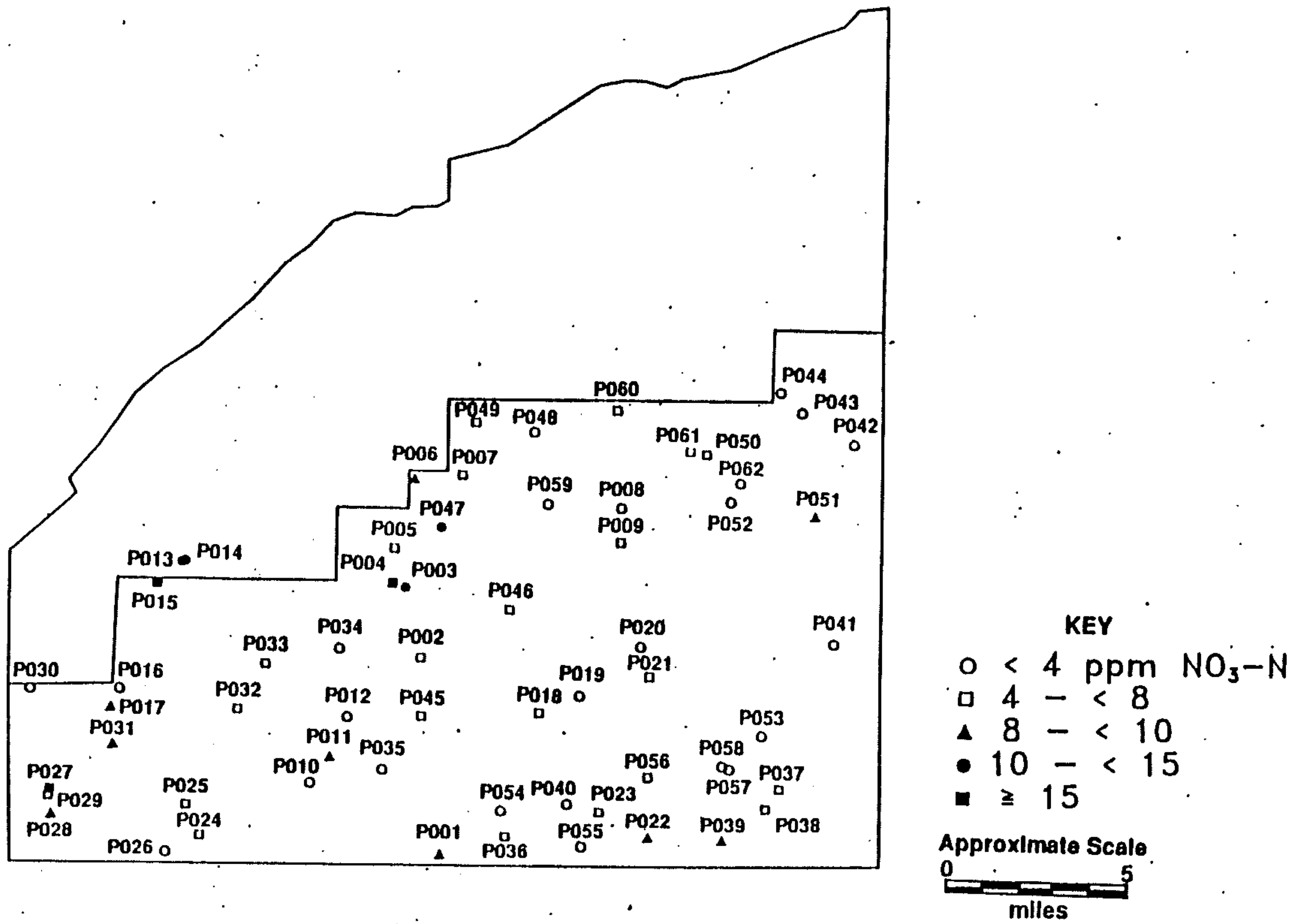
Fillmore County Sampling Locations



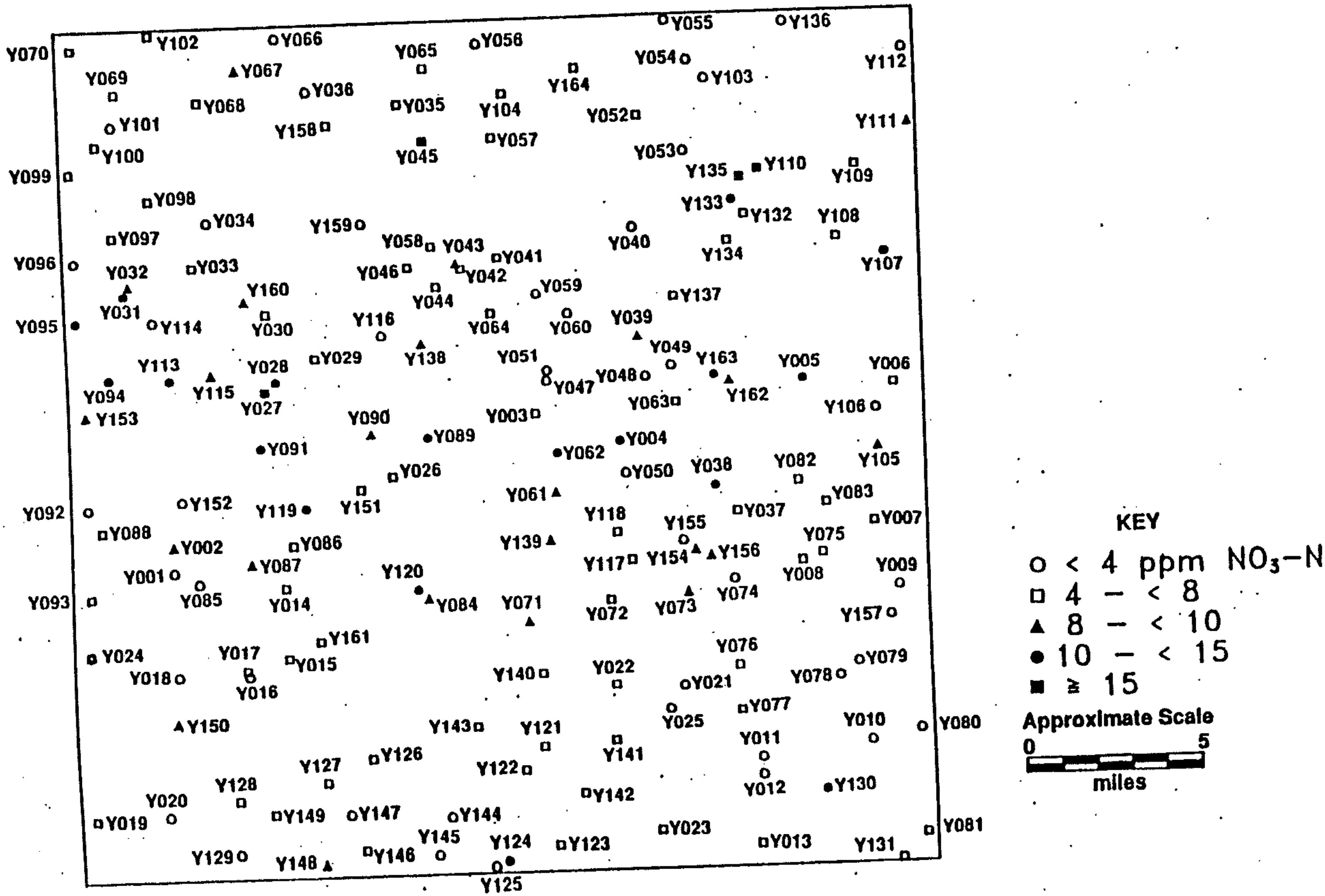
Hamilton County Sampling Locations



Polk County Sampling Locations

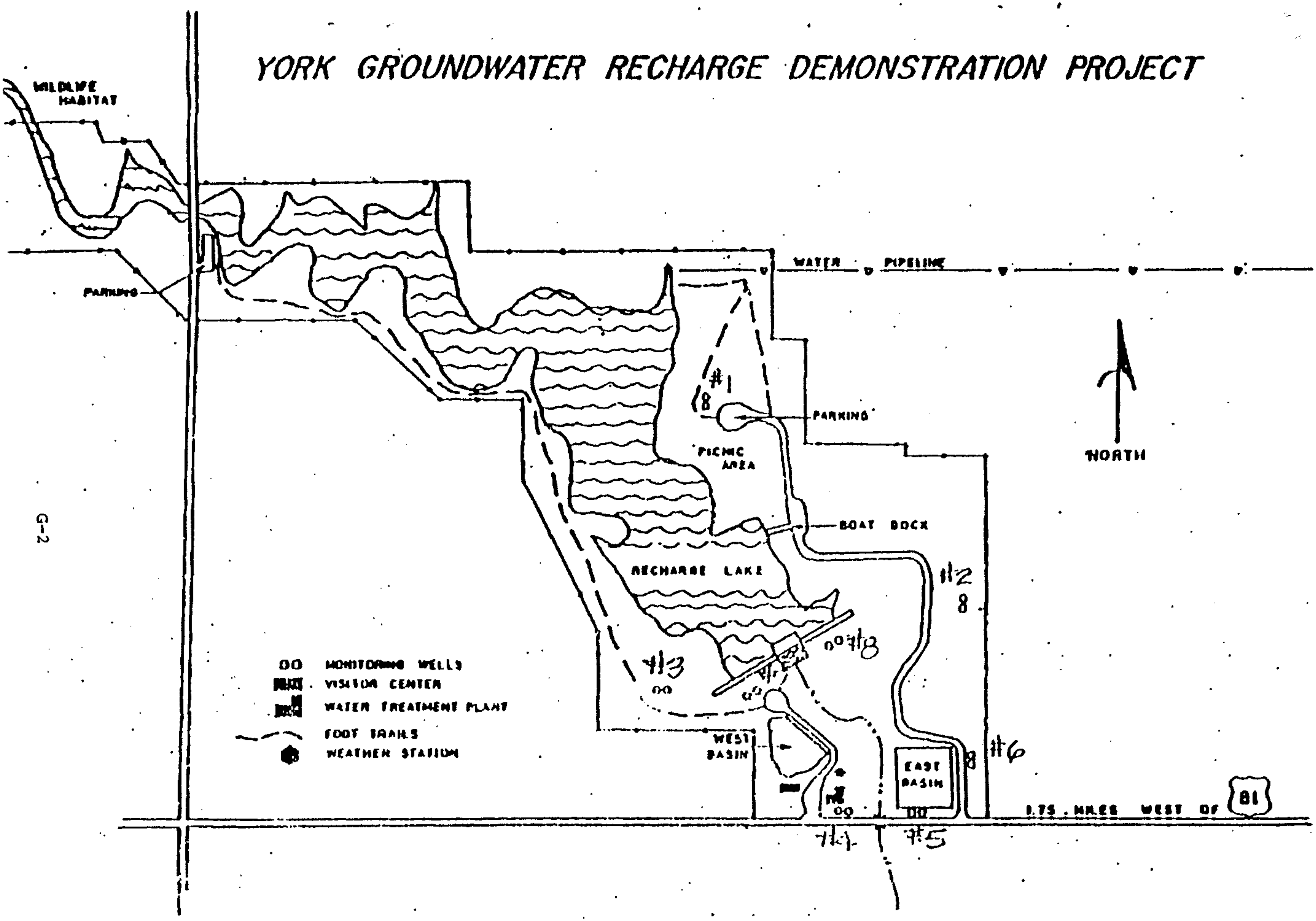


York County Sampling Locations

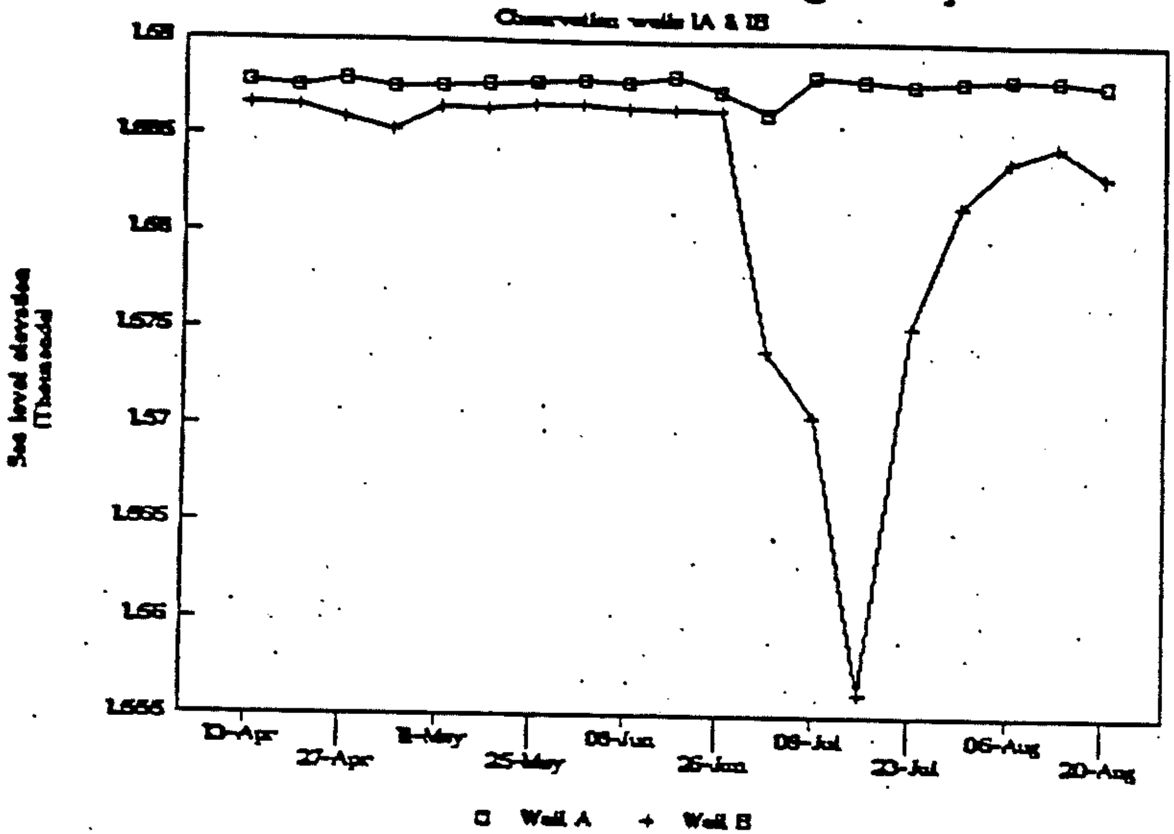


Appendix G. York Ground Water Recharge Demonstration Project Data

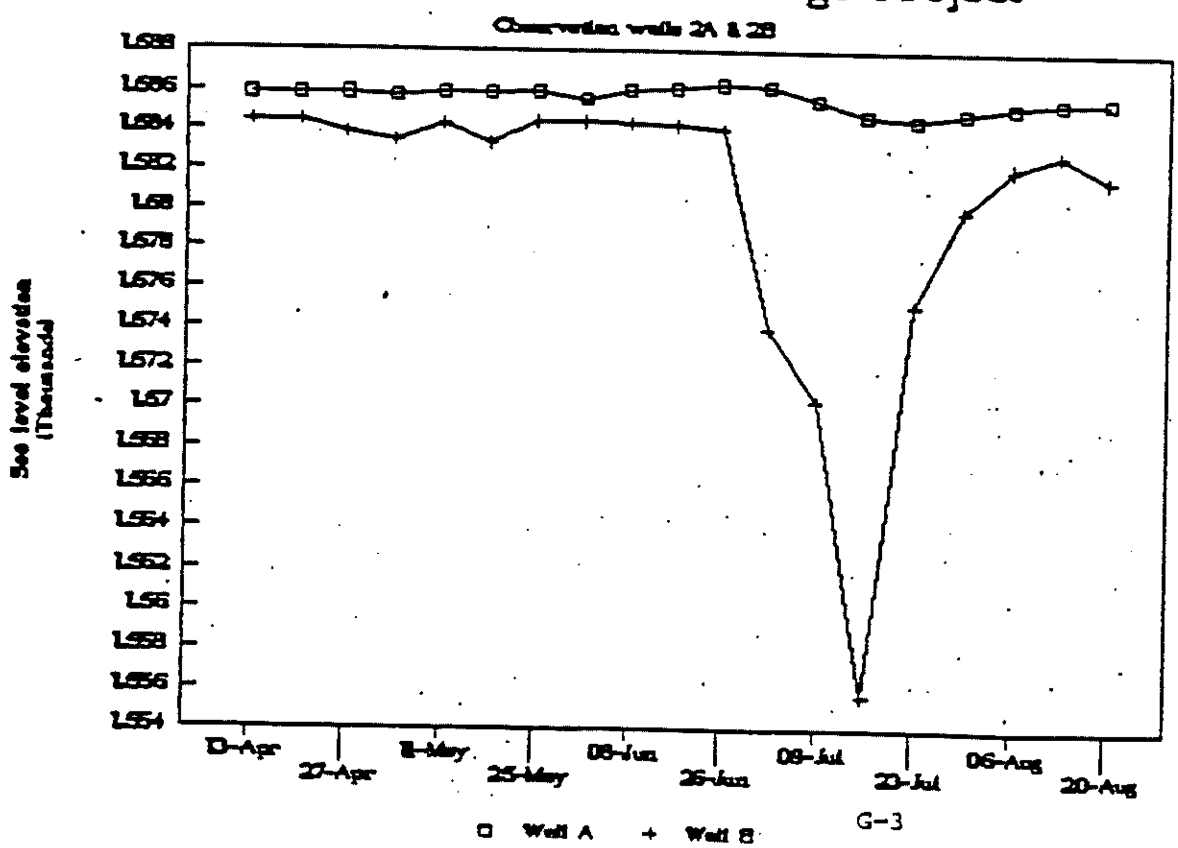
YORK GROUNDWATER RECHARGE DEMONSTRATION PROJECT



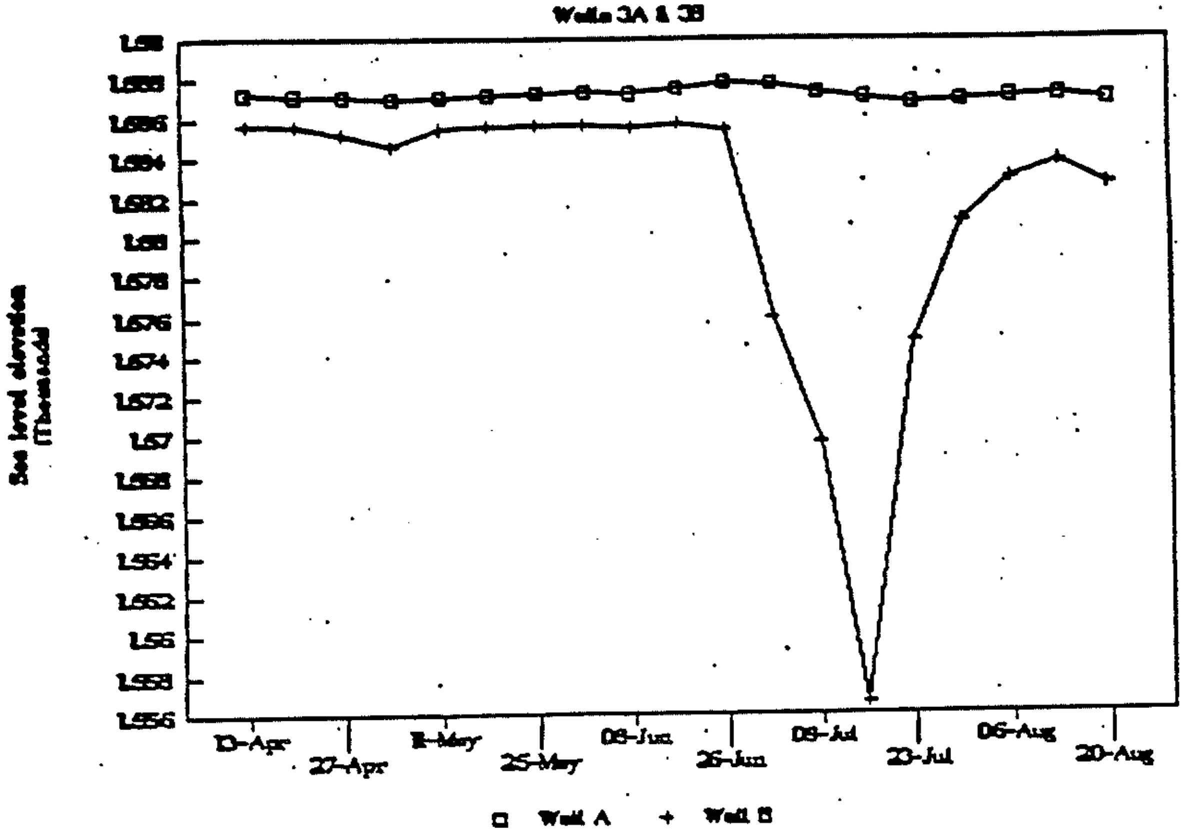
York Groundwater Recharge Project



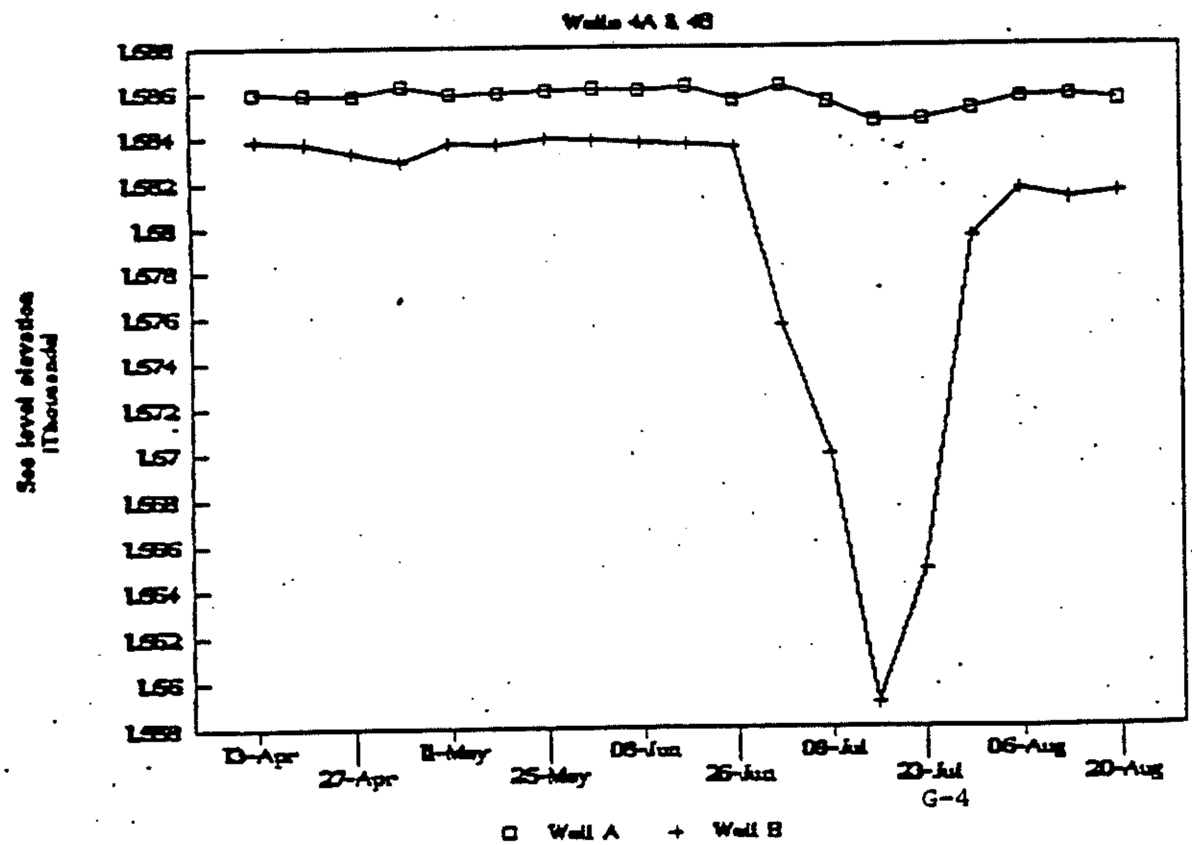
York Groundwater Recharge Project



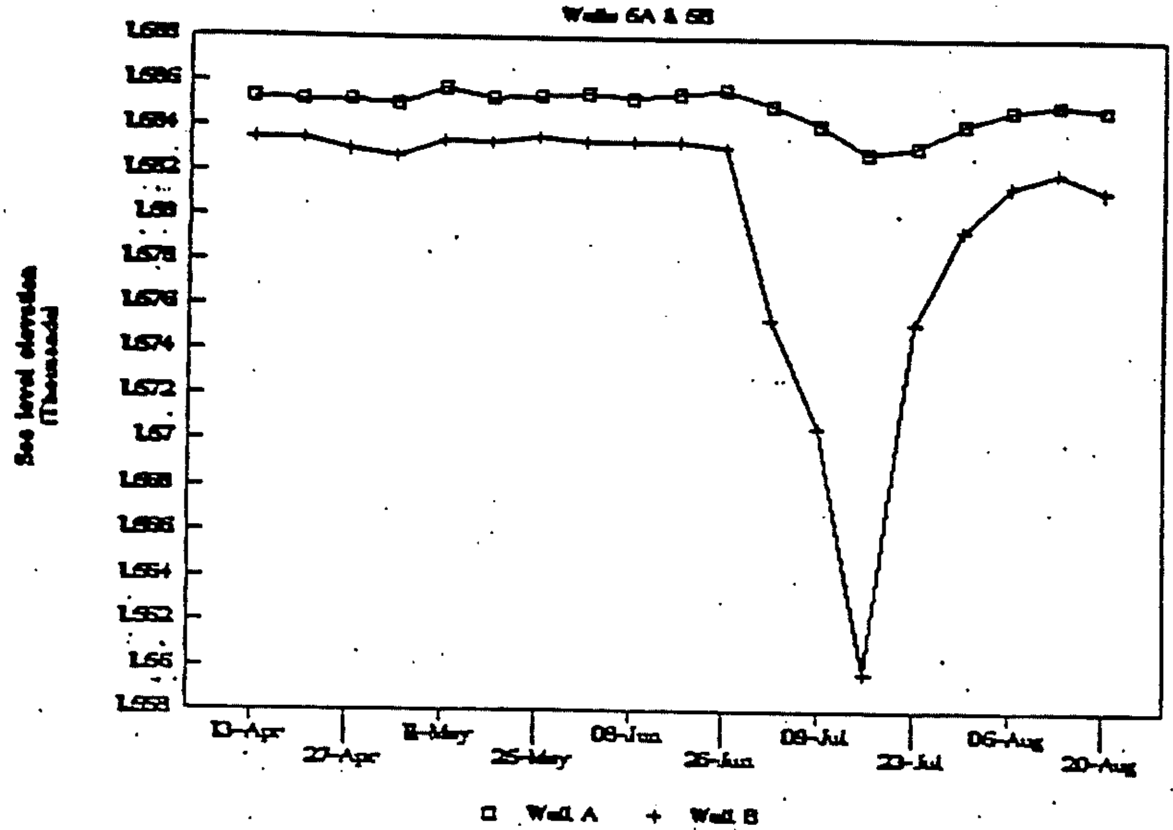
York Groundwater Recharge Project



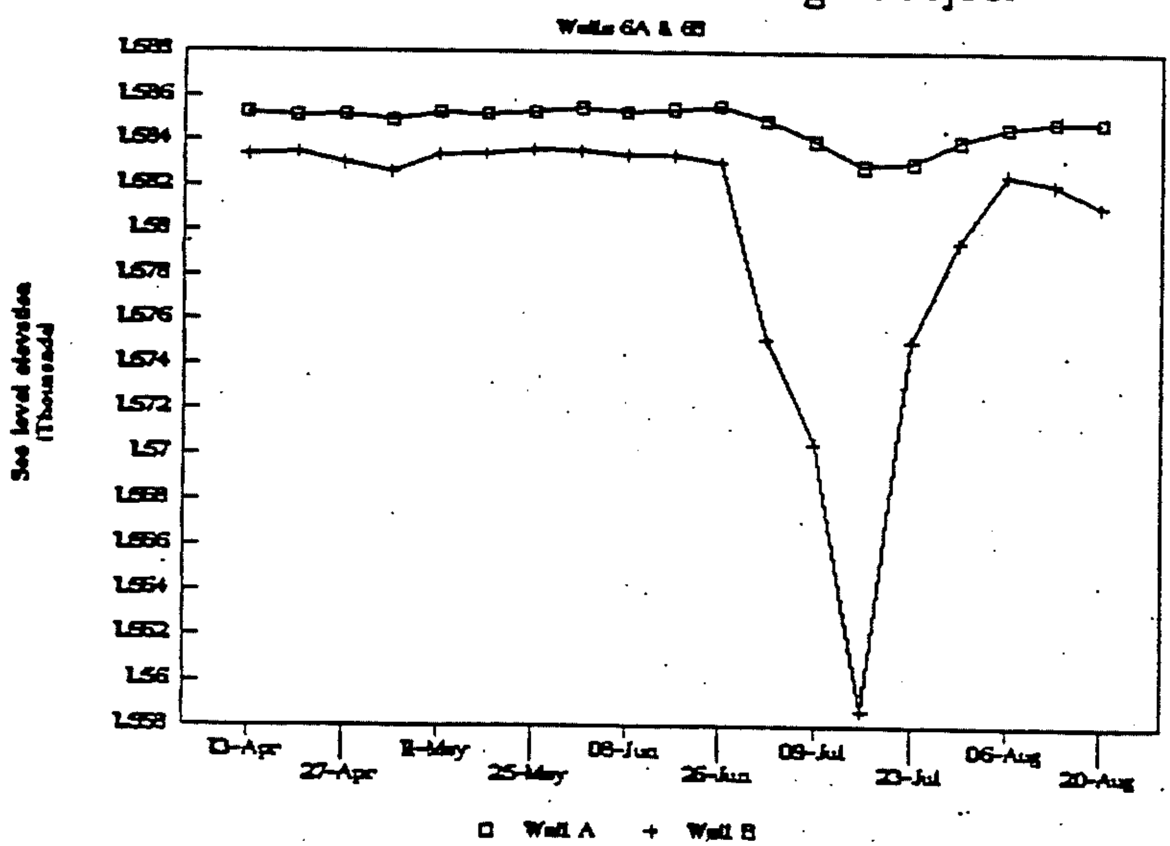
York Groundwater Recharge Project



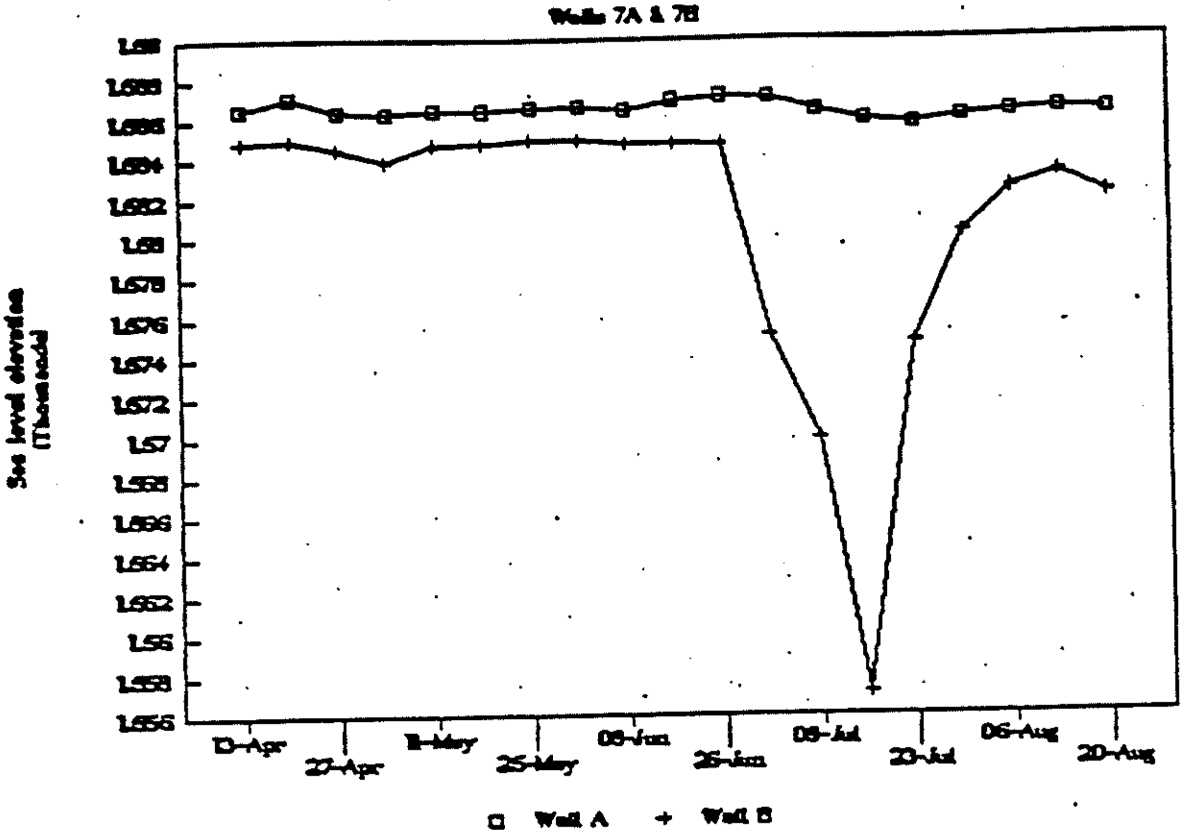
York Groundwater Recharge Project



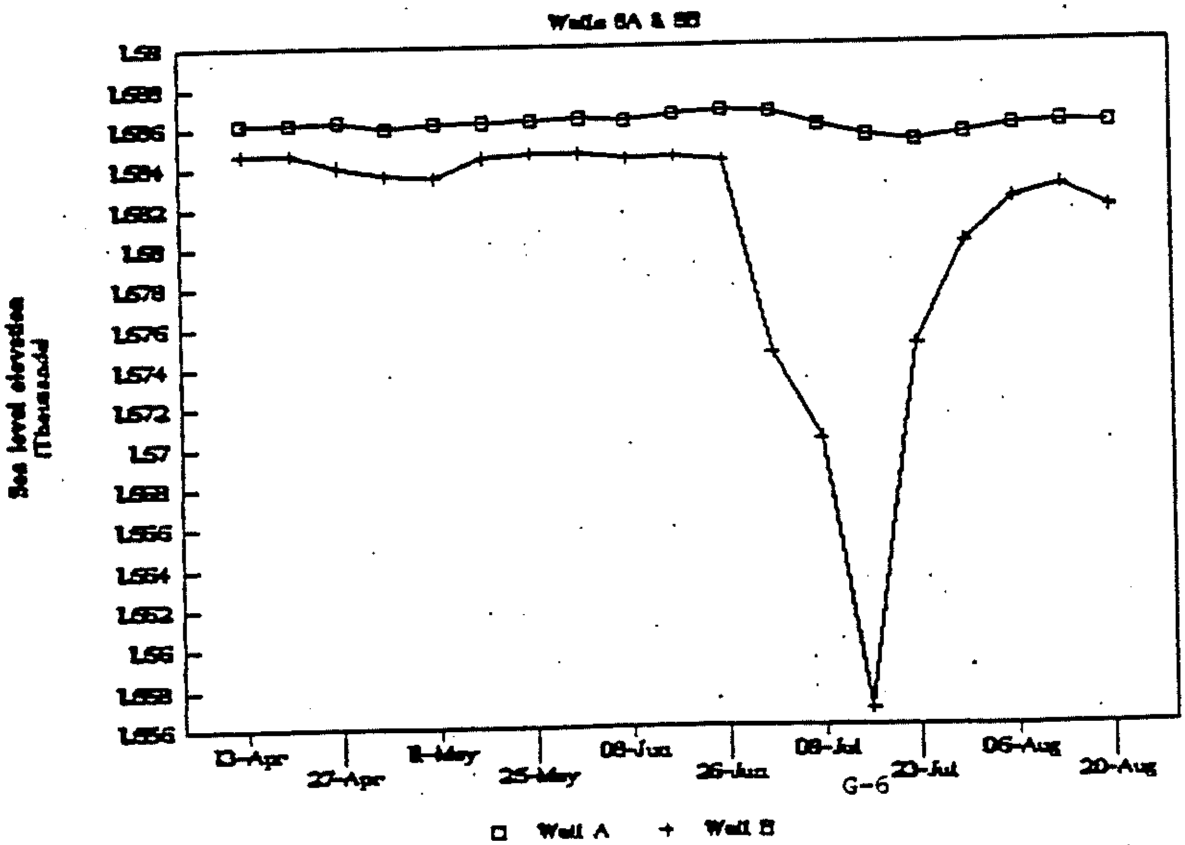
York Groundwater Recharge Project



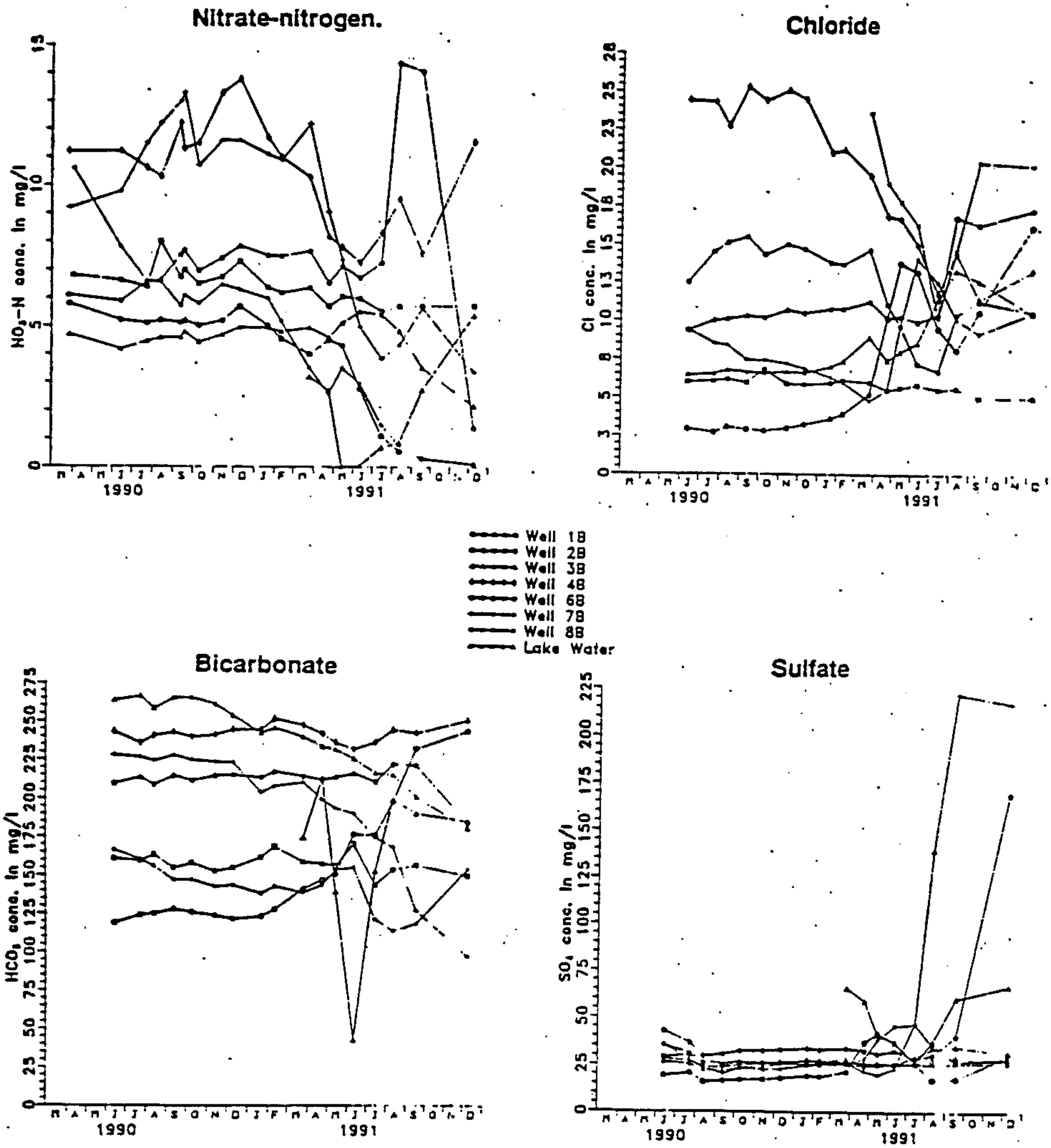
York Groundwater Recharge Project



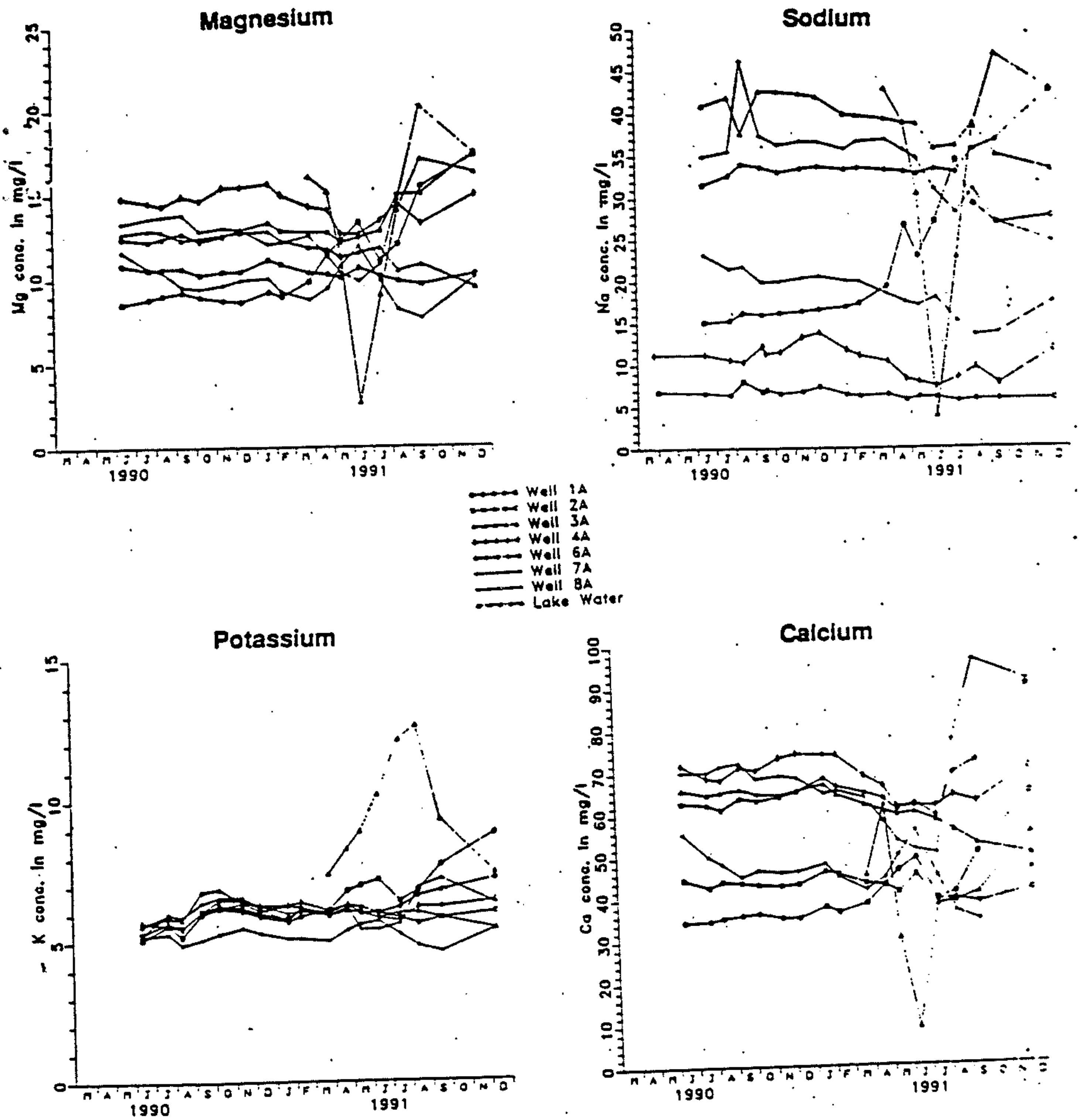
York Groundwater Recharge Project



G-6



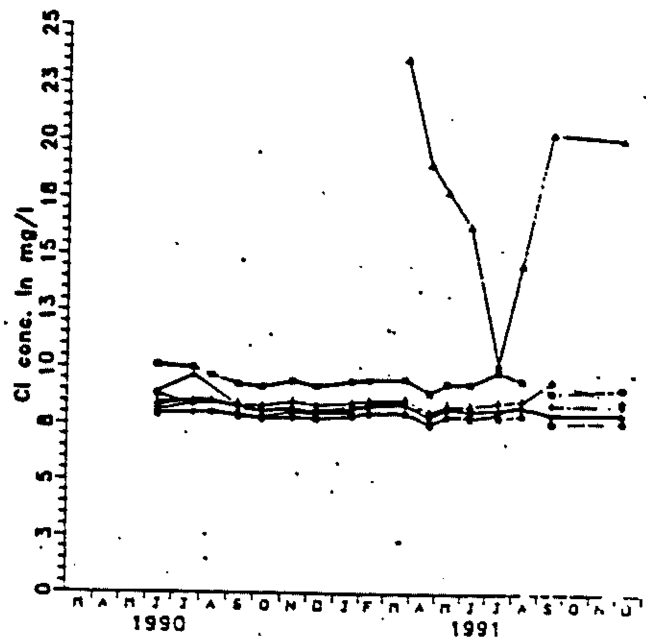
Temporal variation in anionic composition of ground water in shallow wells, York Ground Water Recharge Demonstration Site.



Temporal variation in cationic composition of ground water in shallow wells, York Ground Water Recharge Demonstration Site.

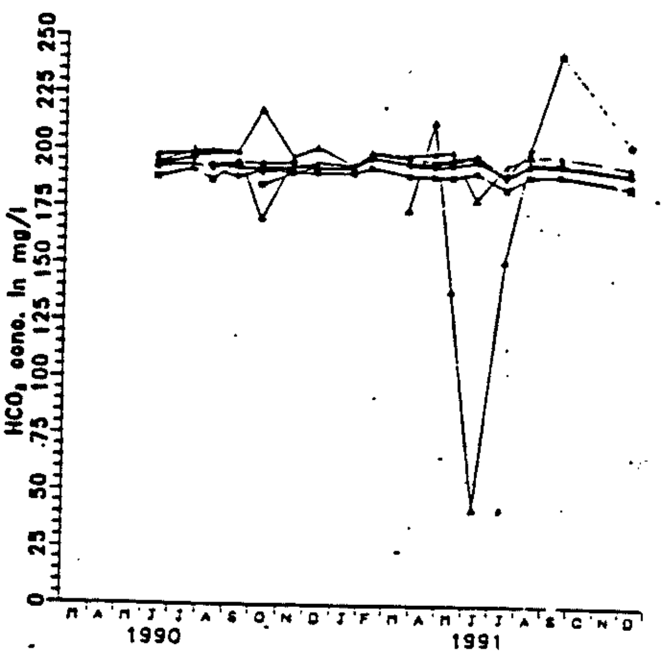
Nitrate-nitrogen concentrations below method detection level for period.

Chloride

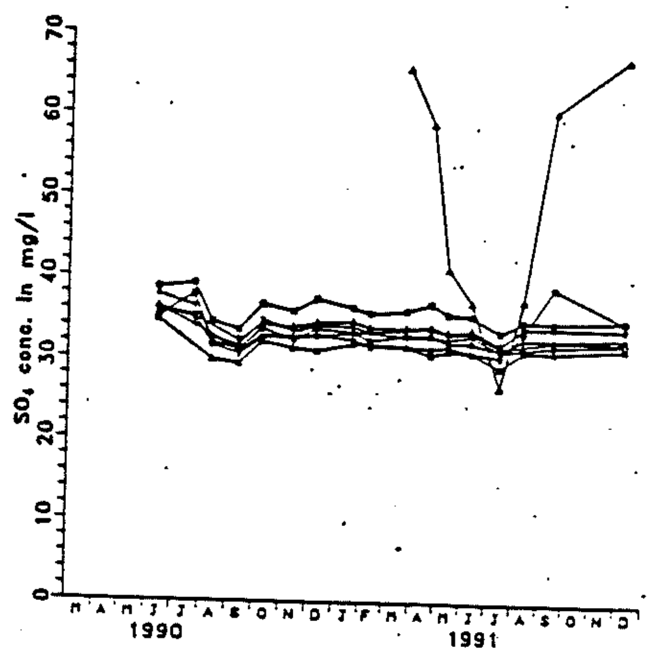


Well 1B
Well 2B
Well 3B
Well 4B
Well 6B
Well 7B
Well 8B
Lake Water

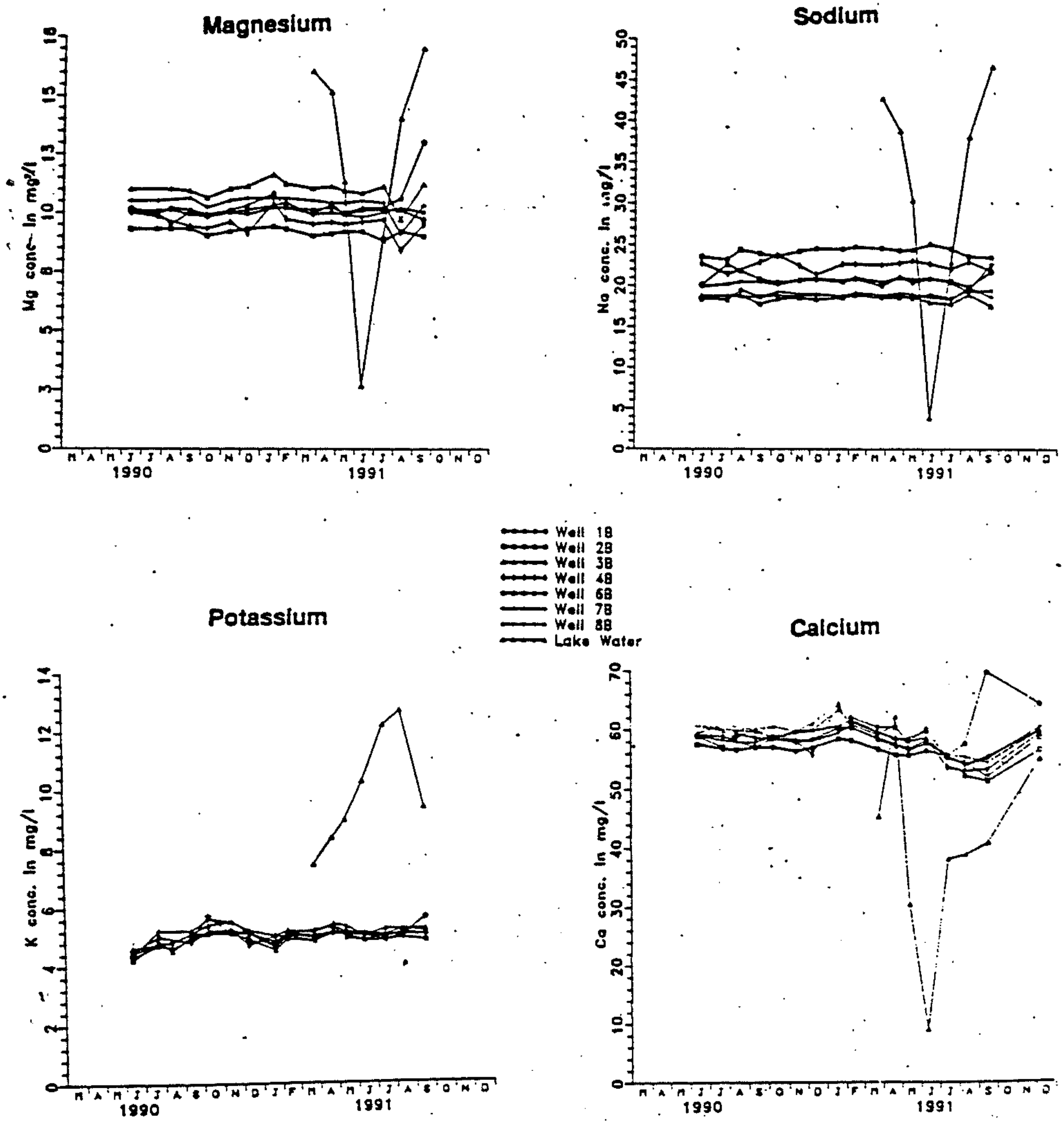
Bicarbonate



Sulfate

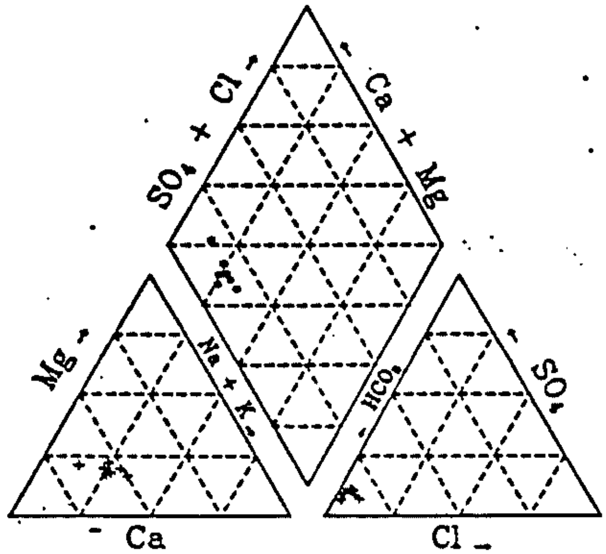


Temporal variation in anionic composition of ground water in deep wells, York Ground Water Recharge Demonstration Site.

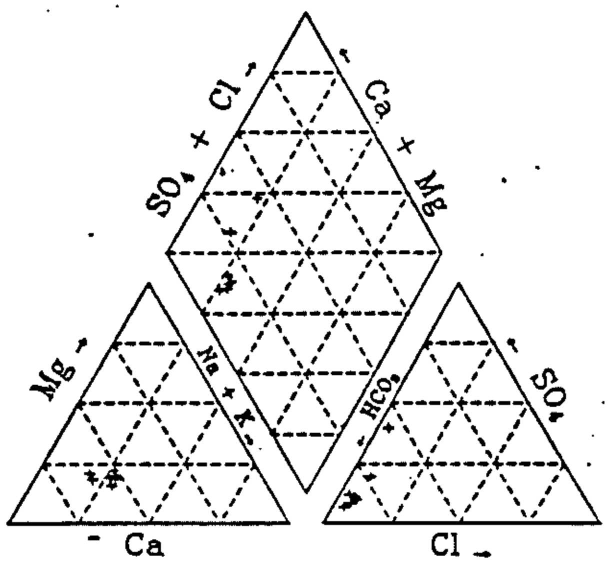


Temporal variation in cationic composition of ground water in deep wells, York Ground Water Recharge Demonstration Site.

Shallow Wells, August 1990
York Recharge Site



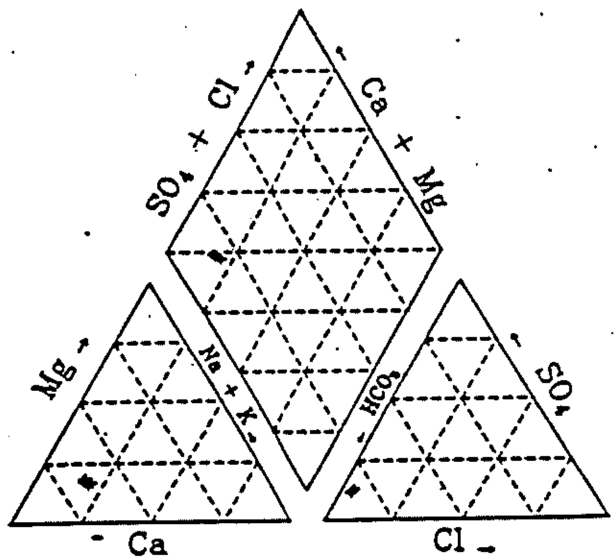
Shallow Wells, August 1991
York Recharge Site



Percent of total milliequivalents per liter.

Ionic composition of sampled ground water in shallow wells, York Ground Water Recharge Demonstration Site.

Deep Wells, August 1991
York Recharge Site



Percent of total milliequivalents per liter.

Ionic composition of sampled ground water in deep wells, York Ground Water Recharge Demonstration Site.