PAPIO-MISSOURI RIVER
NATURAL
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DISTRICT

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March 17, 1994

Dear Reader:

The Papio-Missouri River Natural Resources District is pleased to publish this Groundwater Management Plan. The District hired the consulting firm of HDR Engineering, Inc. to assist in the preparation of the plan. District staff coordinated this effort.

In 1991, the Legislature enacted LB 51 which amended the Nebraska Groundwater Management and Protection Act to require natural resources districts to revise their groundwater management plans giving water quality and quantity equal emphasis. The revised plan was to be submitted to the Nebraska Department of Water Resources (DWR) for approval by July 1, 1993. A Public Hearing was held, and the Board of Directors adopted the plan on June 10, 1993. It was submitted to DWR on June 29, 1993.

DWR required additional elements in the quantity portion of the plan prior to granting approval. A Public Hearing on the quantity plan was held, and the Board adopted the revised plan on December 9, 1993. It was submitted to DWR for review. After minor revisions in February, the plan received approval from DWR on March 11, 1994.

The management and protection of groundwater resources in the Papio-Missouri River NRD remains a vital task and a challenge we must not ignore. The implementation of the plan will add to our knowledge about groundwater in the District and provide a sound basis for water quantity and quality decisions in the future.

With your assistance, we are ready for this challenge.

Optimistically,

Robert W. Bell
Chairperson of the Board

Steven G. Oltmans
General Manager

# PAPIO-MISSOURI RIVER NATURAL RESOURCES DISTRICT

# GROUNDWATER MANAGEMENT PLAN

**PREPARED BY**

**PAPIO-MISSOURI RIVER NRD BOARD OF DIRECTORS AND STAFF**

**AND**

**HDR ENGINEERING, INC.**

**MARCH, 1994**

Approved by the Nebraska Department of Water Resources
March 11, 1994

**ABSTRACT**

The Papio-Missouri River Natural Resources District's (P-MRNRD) policy direction is to maintain the status quo of its groundwater reservoir quantity and quality, forever.

To achieve this reservoir life goal, information has been gathered and presented in this Groundwater Management Plan. This information bears out the P-MRNRD's original hypothesis: Relatively little groundwater data are available specific to this NRD. Available data strongly suggest: 1) groundwater quantity is not now nor will it be a problem in the foreseeable future, and 2) groundwater quality information for several measurable parameters are deficient and remain to be addressed.

Available technical data clearly indicates it would be premature to attempt establish a management, control or special protection areas based upon quantity issues. It would be similarly premature to establish a groundwater quality management or control area prior to determining if a quality problem exists or is likely to exist.

To resolve some of the unanswered technical questions necessary to maintain our reservoir life goal, the P-MRNRD will commit to: 1) maintain the District's static water level monitoring program, 2) establish a District-wide groundwater quality monitoring program, 3) administer the Nebraska Chemigation Act in the District; 4) encourage, through information and education activities, conservation of water quantity and quality; 5) establish management, control or special protection areas in the District to address problems of groundwater quality, should the data collected indicate that the reservoir of goal cannot be met; 6) establish management or control areas in the District to address problems of groundwater quantity should the data collected indicate that the reservoir life goal cannot be met; 7) continue to evaluate requests (petitions) from rural landowners for a more adequate and dependable water supply; 8) cooperate with other NRDs in the management of contiguous portions of the groundwater reservoir; 9) establish a well abandonment cost sharing program in the District; and 10) encourage development of regional water supplies in the District.

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## 1.0 INTRODUCTION

Beginning in 1975 with the passage of the Groundwater Management Act and furthered by the passage in 1984 of the Groundwater Management and Protection Act (GWMPA), the state legislatively recognized groundwater as one of its most valuable natural resources requiring sound management practices to insure future sustainability. Initially, groundwater legislation provided for examination of groundwater quantity problems and established a pattern of local control through delegated authority to the Natural Resource Districts (NRDs). In 1984, the state passed LB 1106 which required the NRDs to prepare groundwater management plans specific to their area and submit these plans to the Nebraska Department of Water Resources (DWR) for approval. In the past few years, a policy evolved with the emphasis shifting from water quantity to water quality. In 1991, LB 51 was enacted, requiring NRDs to expand their management plans to include groundwater quality protection and submit revisions for approval to the DWR.

The basic purpose of these Groundwater Management Plans is to identify the sources and levels of groundwater contamination within an NRD boundary, to establish groundwater quality goals, as well as a goal for the life of the groundwater reservoir, and to develop long-term solutions necessary for the prevention and/or reduction of high levels of groundwater contaminants posing environmental and health hazards. The plans further include recommendations of suitable practices and programs to stabilize, reduce, and prevent the occurrence, increase, or spread of groundwater contamination.

The Papio-Missouri River Natural Resources District (P-MRNRD) has prepared this Groundwater Management Plan to comply with the provisions of the GWMPA (LB 1106) and LB 51. Since the management of both quantity and quality for ground and surface waters has always been a priority of the District, this requirement complements longstanding District policy. This Groundwater Management Plan will be maintained as a growing and dynamic document consistent with the evolving understanding of the groundwater resource limitations within the District. It is intended to provide a basis for decisions concerning the need for, and usefulness of, alternative corrective and preventive actions to be implemented within the District.

When evaluating the preparation process and content of these plans, one disadvantage must be recognized. In certain areas there is a lack of good scientific knowledge about groundwater systems. The subsurface environment of groundwater involves a complex interplay of physical, geochemical and biological forces which vary from place to place dependent on climatic, demographic and hydrogeologic factors. When analyzing quality of these systems, spatial and temporal trends are often further complicated by the effect of both natural phenomena and anthropogenic activities. Research projects and investigations on these systems have recently been increasing with objectives ranging from technological improvements for the assessment of the subsurface and chemical behavior in geologic materials to state-of-the-art remedial techniques.

As such, this Plan should also be viewed as a resource document presenting available technical and research information in a convenient form for utilization by relevant decision makers and other interested persons or organizations. The continual incorporation of new data will ensure that uncertainties do not undermine predictions and actions formulated by the District.

The framework for nonpoint source groundwater include: 1) evaluate existing and potential sources of groundwater contaminations; 2) prepare comprehensive description of the quality and vulnerability of the groundwater; 3) develop the programs and identify practices that would be most effective in handling areas of existing and potential groundwater contamination; and 4) evaluate the groundwater monitoring program to determine the most efficient use of resources which will, in turn, enable the P-MRNRD to more effectively understand and react to existing or potential groundwater contamination.

## 1.1 General Document Format

The P-MRNRD's Groundwater Management Plan follows the format suggested by the Conservation and Survey Division's Handbook for the Preparation of Groundwater Management Plans. The Plan is divided into the following sections: Hydrogeologic Characterization; Groundwater Quality; Land Use and Contamination Source Inventory; Water Usage and Demand; Identification of Critical Areas for Protection; and Groundwater Quality Goals and Objectives. Appendices include all pertinent supplemental materials and references.

Technical information on groundwater resources is readily available for a statewide region, but detailed information specific to this District is only minimally available at this time. As such, the technical sections of this Plan will provide general information for the entire District and specific information for limited areas. Where technical data is currently undeveloped, it will be so stated.

## 1.2 General Area Description

The P-MRNRD encompasses approximately 1,790 square miles within six counties: Washington, Douglas and Sarpy in their entirety, most of Dakota County, the eastern 61 percent of Thurston County, the eastern 56 percent of Burt County, and a small portion of southeast Dodge County. The delineation of the P-MRNRD is shown in Figure 1.

Portions of three major riverbasins are contained within the P-MRNRD: the Missouri, the Platte and the Elkhorn. The District is bounded by the Missouri River on the east and north, by the Platte River on the south and west, and by tributaries to both waterways on the west. The predominant tributary waterways running through the northern counties of Dakota, Thurston and Burt include Elk, Omaha, Pigeon, Blackbird, Elm, Mud and Tekamah Creeks. Because baseflow on these creeks is relatively low, extended dry periods may considerably reduce flows. The Papillion Creek basin lies entirely within the District.

Population totals for 1990 within the District are approximately 560,500. Figure 2 shows the population distribution within the District. Approximately 75% of the District's population reside in Douglas County, while less than 1% resides in Burt and Thurston Counties. All population centers within the District having greater than 1,000 residents are located either adjacent to or within a few miles of the Missouri or Platte Rivers. These include South Sioux City, Dakota City, Tekamah, Arlington, Blair, Bellevue, Elkhorn, Gretna, Omaha, LaVista, Papillion and Valley.

Topographically, the District consists of open and rolling loess hills accentuated with a precipitous bluffline rising abruptly from the broad flat Missouri River flood plain (Figure 3). These bluffs range in height from small banks to 200 feet cliffs extending from the river valley floor to over five miles inland. In most areas, the landscape becomes subdued at the top of the bluffs.

The soils vary considerably in types, textures and relief (Figure 4). The majority of the soils are deep, well drained to excessively drained, gently sloping to very steep, silty and loamy, formed in loess and colluvium on the uplands and foot slopes. A portion of the soils are deep, well drained to excessively drained, strongly sloping to very steep, silty and loamy, formed in loess and glacial till on the uplands. There are some small areas of shale and sandstone outcrops in the uplands. The soils of the Missouri River bottom are deep, poorly drained to excessively drained, nearly level and gently sloping silty, clayey and sandy, formed in alluvium on bottomlands.

The majority of the hills are devoted to pasture and row crops with the flat, bottomlands of alluvial soils utilized principally for crop production. Woodlands are common throughout the numerous stream courses, bluffs and some areas of the flood plain.

The P-MRNRD receives, in most years, sufficient moisture in the form of snow and rainfall to effectively negate the need for major irrigation development. Similarly, ample water supplies for both industrial and municipal usage are available for the major population centers (South Sioux City, Dakota City, Tekamah, Blair, Omaha, and Bellevue) from well fields in the alluvial aquifer along the Platte or Missouri Rivers, or directly from the Missouri River. Replenishment of the aquifer appears to be continuous.

This abundance of precipitation and surface water supplies, coupled with the relatively complex nature of the area geology and stratigraphy, has historically minimized research concerning groundwater conditions in the District. Also, minimal effort has been made to collect groundwater data in the District. Consequently, other than generalities, the data required to address many of the technical questions specific to the District are not available. Designing studies to collect missing technical data may not be necessary or feasible.

A complete description of the water supply sources available in the District is necessary so that groundwater management decisions can be systematically and logically made. This Plan is based upon available data and describes the characteristics of both ground and surface waters.

## 2.0 HYDROGEOLOGIC CHARACTERIZATION

Hydrogeology can be defined as the study of groundwater with particular emphasis given to its chemistry, mode of migration, and relation to the geologic environment. Groundwater occurs in many types of geologic formations; aquifers are of most importance. An aquifer is defined as a formation that contains sufficient saturated permeable material to yield significant quantities of water. These groundwater bearing formations store and transmit water. Generally, aquifers are areally extensive, and may be overlain or underlain by a confining bed. This confined bed may be defined as a relatively impermeable material stratigraphically adjacent to one or more aquifers. Table 1 summarizes characteristics of the nine hydrogeologic units of the P-MRNRD area.

### 2.1 Aquifer Description

Beneath the land surface, water occurs in two distinct zones: the zone of aeration and the zone of saturation. The zone of aeration lies immediately beneath the land surface containing both air and water in the pore spaces. The zone of saturation lies beneath the zone of aeration and contains only water in the pore spaces. The boundary between these two zones is commonly referred to as the water table. For the purposes of this section, the term groundwater will apply to water occurring in the zone of saturation.

Within the zone of saturation, groundwater is found in both consolidated (bedrock) and unconsolidated (glacial till or alluvium) materials. For the purposes of this Plan, the groundwater reservoir will be considered as that portion of the zone of saturation occupied by unconsolidated materials, and the secondary reservoirs as those occurring in consolidated materials. (In the literature, the term "principal aquifer" is used frequently. In this section, groundwater reservoir is used as a replacement term for principal aquifer.)

**Table 1. Hydrogeologic Units in the P-MRNRD**

| Era | System | Geologic Unit | Character and Distribution | Hydrogeologic Unit | Hydrogeologic Information |
|---|---|---|---|---|---|
| Cenozoic | Quaternary | Undifferentiated Holocene and Pleistocene deposits | Clay, silt, sand, and gravel. Includes eolian, glacial, and alluvial deposits that overlie the NRD, except in small areas where bedrock crops out. Thickness is variable. Deposits in river valleys usually are less than 100 feet thick. In upland parts of NRD most deposits are between 50 and 250 feet thick. Maximum thickness, about 300 feet, is in northern part of NRD. Eolian deposits are loess, silt and clay-sized grains, that are the surficial deposits in most upland parts of the NRD. Loess thickness usually ranges from 10 to 50 feet. Glacial deposits are clay tills that are silty, sandy, and gravelly and occur under upland areas of NRD. Multiple till beds occur, and total thickness usually is 25 to 125 feet, but may be as much as 175 feet or be absent due to erosion. Alluvial deposits include clay, silt, sand, and gravel. Clay and silt deposits usually are intermixed or interbedded with sand and gravel deposits. Sand and gravel deposits are most common in river valleys. | Missouri River valley alluvial aquifer | Aquifer usually unconfined, but locally may be partially confined. Most wells yield 600 to 1,200 gal/min. Depth to water ranges from 5 to 15 feet, and saturated thickness ranges from 70 to 100 feet. |
| | | | | Platte River valley alluvial aquifer | Unconfined aquifer with wells yielding 900 to 2,000 gal/min. Depth to water ranges from 5 to 15 feet, and saturated thickness ranges from 60 to 100 feet. |
| | | | | Elkhorn River valley alluvial aquifer | Unconfined aquifer with wells yielding 700 to 1,200 gal/min. Depth to water ranges from 5 to 15 feet, and saturated thickness ranges from 50 to 90 feet. |
| | | | | Uplands area alluvial aquifers | Confined or partially confined discontinuous beds of saturated sand and gravel. Well yields range from 10 to 300 gal/min. Depth to water ranges from 30 to 150 feet, and the thickness of saturated sand and gravel beds usually is less than 20 feet. |
| Mesozoic | Cretaceous | Undifferentiated Carlile Shale, Greenhorn Limestone, and Graneros Shale | Shale, marl, and limestone. Shale is calcareous. Limestone is thin-bedded argillaceous and is interbedded with marl and shale beds. Maximum thickness about 125 feet. | Cretaceous confining beds | Forms a regional confining bed that, where present, separates Dakota aquifer from aquifers in Quaternary deposits. |
| | | Dakota Formation | Sandstone and claystone. Sandstone is very fine to coarse grained, lenticular and friable. Locally cement is iron oxide. About 70 percent of formation is sandstone. Claystone is massive, and often silty. Maximum thickness, about 500 feet, is in Dakota and Thurston Counties where the formation is overlain by the Graneros Shale. In the rest of the NRD the Dakota thins towards the south and east because of erosion. Erosional remnants less than 20 feet thick occur in Sarpy County. | Dakota aquifer | Confined or partially confined aquifer with wells yielding 10 to 600 gal/min depending on the thickness of saturated sandstone. Depth to water ranges from 15 to 100 feet, and the sandstone thickness from less than 1 foot to about 300 feet. |

**Table 1. Hydrogeologic Units in the P-MRNRD**

| Era | System | Geologic Unit | Character and Distribution | Hydrogeologic Unit | Hydrogeologic Information |
|---|---|---|---|---|---|
| Paleozoic | Pennsylvanian | Undifferentiated limestone, shale, and sandstone beds | Limestone and shale. Limestone is thin bedded to massive, and usually dense. Shale is calcareous and fissile. Maximum thickness 400 feet in southeastern Washington County and northwestern Douglas County. Absent in Dakota and Thurston Counties and the northern part of Burt County. | Paleozoic confining beds | Forms a regional confining bed that, where present, separates the lower Paleozoic aquifer system from the Dakota aquifer or from aquifers in Quaternary deposits. Wells completed in local fracture zones near the top of the beds may yield 5 to 50 gal/min. |
| | Mississippian-Cambrian undifferentiated | Undifferentiated limestone, dolomite, and sandstone beds | Dolomite. Predominantly massive bedding with some limestone beds in upper part, thin dolomitic shales in the middle and sandstone beds in the lower part. Thickness ranges from about 900 feet in Dakota County to 1,600 feet in Washington County, to 1,100 feet in Sarpy County. | Lower Paleozoic aquifer system | Confined aquifers. Available information indicates that well yields range from 200 to 1,300 gal/min, water levels from 150 to 300 feet below land surface, and well depths from 1,100 to 2,400 feet. |
| Precambrian | Undifferentiated | Undifferentiated | Undifferentiated igneous, metamorphic, and sedimentary rocks. | Precambrian confining beds | Regional base of lower Paleozoic aquifer system. |

Source: U.S. Geologic Survey, provisional data, March 1993.

Therefore, the principal groundwater reservoir is defined as that portion of the zone of saturation located between the upper surface of the bedrock (consolidated material) and the water table. The University of Nebraska-Lincoln (UNL) Conservation and Survey Division (CSD) in 1979 and Nebraska Department of Environmental Quality (NDEQ) have jointly published maps of the groundwater reservoir. The configuration of the base of the groundwater reservoir (upper surface of the bedrock) is shown in Figure 5. Although the water table level fluctuates from year to year, the control points used for delineating the upper surface of the groundwater reservoir were set at the spring 1979 water levels (Figure 6). Figure 7 represents the thickness of the groundwater reservoir.

**Bedrock (consolidated materials)**

The uppermost bedrock under the District is of either Pennsylvanian or Cretaceous Age (Figure 8 and Table 1). The Pennsylvanian system is the oldest of these two systems. The major bedrock groups of this system are shale and limestone. Pennsylvanian rocks outcrop in places along valley sides, and limestone from this formation has been quarried extensively in southern Sarpy County and less extensively in eastern Douglas and Washington Counties. They are also found in buried valleys at other locations where the Dakota Sandstone has been removed by erosion.

Pennsylvanian and Cretaceous systems form the base of the groundwater reservoir in the entire Missouri River Valley, the portion of the Platte River Valley below the Elkhorn River, and a portion of the upland area of the District. Generally, rocks of Pennsylvanian Age are not considered to be a source of water.

Older Paleozoic rocks of Mississippian, Devonian, Silurian, Ordovician, and Cambrian age underlie the entire District. In the past, carbonate rocks primarily of pre-Mississippian Age and basal sandstones of Paleozoic Age were used as a source of water for industrial use; however, most of these sources have now been abandoned.

The Dakota Sandstone formation of Cretaceous Age underlies most of the western two-thirds of the southern three county area where it is the uppermost bedrock. Dakota rock types range from pebble gravels to sandstones and shales. Outcrops of this formation can be found on lands along the Platte River in Sarpy County and occasionally exposed elsewhere in both Sarpy and Douglas Counties. At these outcrop locations, the groundwater reservoir is very thin or absent (Figure 7). Dakota Sandstone underlies the majority of the upland portion of the District and that portion of the Platte River Valley above the mouth of the Elkhorn River.

Groundwater occurring in consolidated materials (bedrock) are considered to be secondary reservoirs in this Plan. The Dakota Sandstone Aquifer is a bedrock water source utilized in eastern Nebraska (Ellis, 1982) and an important source of water to many domestic, municipal, irrigation, and industrial wells. Well yields range from ten to as much as six hundred gallons per minute. Where the unconsolidated material (groundwater reservoir) is thin or absent, the Dakota is the only source of usable water. A number of wells extend into this aquifer which is an asset to those landowners with no other source of water. Also, several deep wells into pre-Pennsylvanian Paleozoic rocks have been used in the past as an industrial water supply in the Omaha area.

**Alluvium (unconsolidated materials)**

Unconsolidated materials overlie the bedrock in varying thicknesses. Figure 9 shows the thickness of quaternary deposits overlying bedrock in Washington, Douglas and Sarpy Counties. These deposits of sands, gravels, glacial till and loess were influenced by several glaciation periods. The thickness of these deposits ranges from 300 feet in northwest Washington County to 100 feet or less along the major river valleys.

The unconsolidated materials in the Platte River and Missouri River Valleys overlying the bedrock are approximately 100 feet thick. The unconsolidated materials in the remainder of the District above bedrock range in thickness from 100 to 300 feet.

### 2.1.1 Geographic/Areal Description

Nebraska was divided into thirteen underground water areas of which three are represented in the P-MRNRD: the Platte River Valley, the Northeast Nebraska Glacial Drift areas and Missouri River Lowlands (Figure 10). The District's groundwater reservoir can be sub-divided into underground water areas based upon descriptions by Reed (1968).

**Platte Valley**

The Platte Valley area encompasses the flood plain, bottom land and low terraces along the Platte River in its lower part and along the Platte and Elkhorn Rivers in its upper part, collectively referred to as the Platte Valley Region. Large capacity wells can generally be developed from the alluvial deposits (unconsolidated materials) of Pleistocene and Holocene age underlying the Platte Valley area. The total storage of groundwater is large; and, although extensive withdrawal for municipal, industrial and irrigation has occurred, no long term change in storage has been detected (Ellis & Pederson, 1985; Martin & Pederson, 1984). Recharge from precipitation and streamflow appears to be in balance with natural discharge to streams, evapotranspiration and discharge through wells. Some well fields have been developed that induce recharge from the Platte River.

**Northeast Nebraska Glacial Drift Area**

A large portion of the area is occupied by the Northeast Nebraska Glacial Drift Area, named the Upland Region. Deposits of glacial drift as much as 200 feet thick underlie most of the area. Several tens of feet of wind blown silt, known as loess cover much of the Glacial Drift Area. However, glacial till is exposed at the ground surface in the southwestern portion in the northern three counties. The till rests directly on bedrock at some locations, while at others, thick early Pleistocene sands and gravels fill valleys now buried beneath the till. The major modern valleys cut completely through the Pleistocene, exposing the Dakota formation.

Glacial till is a poor source of groundwater. Yields to wells in these deposits are usually small to negligible and the water is usually highly mineralized. However, thick deposits of Pleistocene sand and gravel are sources of medium to relatively large supplies of good quality water for consumption as well as sources of most irrigation wells. Where these Pleistocene aquifers are thin or absent, water may be obtained by drilling into the deeper lying Dakota Sandstone.

The drift rests directly on the Dakota Sandstone, a bedrock of Cretaceous Age in the western portions of Sarpy, Douglas, Washington and Burt Counties and in the eastern part of Thurston and Dakota Counties. This formation is exposed at numerous sites along the Missouri River bluffs. The drift overlays the bedrock of Pennsylvanian Age in the eastern part of Washington, Douglas and Sarpy Counties (Figure 8). In places, buried bedrock valleys contain Pleistocene sands and gravels.

Many domestic and stock wells in the glacial drift are developed in perched aquifers of small areal extent and yield. Other domestic, municipal and industrial wells are developed in sands and gravels of the groundwater reservoir (including confined aquifers) or in the Dakota Sandstone formation where it can be reached at shallow to moderate depths. This formation may also contain isolated gravel beds at its base where moderately large yields can be obtained. In some places, no satisfactory groundwater supply can be obtained.

**Missouri River Lowland Region**

The Missouri River Lowland Area, named the Missouri Valley Region, is also underlain by alluvial deposits of Pleistocene and Holocene age. It occupies the floodplain and low terraces along the Missouri River. Hydrologic characteristics of the groundwater reservoir in the Missouri Valley Region are believed to be similar to those in the Platte Valley region.

The Missouri Valley Region has sufficiently thick Pleistocene sand and gravel deposits to supply numerous large capacity wells. Glacial till deposits as well as the underlying Dakota Sandstone formation also provide an important domestic, irrigation and/or municipal water source.

Water from the Missouri Valley Region while sufficient in quantity for most municipal and industrial uses, is generally highly mineralized with iron content posing a significant quality problem requiring treatment prior to many uses. Areas of particular concern are around South Sioux City and Dakota City in the northeast portions of Dakota County, the area around Fort Calhoun in southeastern Washington County and in eastern Douglas County. Wells located within this area may have total dissolved solids (TDS) concentrations in excess of 1,000 mg/l (Figure 11).

### 2.1.2 Physical Characteristics

#### Transmissivity

The capacity of a groundwater reservoir to transmit water is indicated by transmissivity values. These values are a function of the permeability and the saturated thickness of the reservoir. Transmissivity values may be used to make estimates of well yield in any particular area. However, data required to determine reasonably accurate transmissivities in this area are currently not available. Numerous assumptions, extrapolations and educated guesses have been utilized in evaluating both aquifer thickness and permeability to construct the very generalized view of transmissivity values that are presented in Figure 12.

Although, the values shown in Figure 12 are not site-specific and must be handled with caution, indications are that transmissivity values as a whole would appear to be rather low. Transmissivity values between 20-100 thousand gallons/day/foot are found in the eastern portions of Dakota, Washington, and Burt Counties, while lower estimates, ranging from 0-20 thousand gallons/day/foot can be found in the western portions of Thurston, Dakota, Douglas and Sarpy Counties, and intermittently in Burt and Washington Counties.

Areas with transmissivity values exceeding 20 thousand gallons/day/foot are generally considered capable of sustaining well yields sufficient for irrigation. The relatively low transmissivities in this area are a reflection of the thinness of the principal aquifer in the bluffs and hills along the Missouri River, or the impermeability of the saturated materials farther inland.

The concentration of wells in the Platte Valley and Missouri Valley Areas (Figures 19 and 20), reflect higher transmissivities in these regions than in the Upland Region.

**Saturated Thickness**

Figure 13 shows the approximate saturated thickness of the groundwater reservoir. The thickness represents the difference between the water table elevation in 1979 and the configuration of the base of the principal groundwater reservoir. In the Missouri Valley and Platte Valley Region, the thickness averages approximately 100 feet; in the Upland Region, it can range from minuscule to 200 feet. In numerous locations the groundwater reservoir is completely absent.

## 2.2 Vulnerability Description

Groundwaters underlying the District are vulnerable to contamination through natural and artifical sources. Recharge in the groundwater reservoir occurs naturally, however, no natural recharge areas have been defined.

### 2.2.1 Depth to Groundwater

Distance from the ground surface to the water level varies considerably with both time and location. This information is useful, however, for calculating both pump lift energy consumption and potential groundwater recharge, as well as for environmental considerations.

General statements made regarding depth to groundwater must always be regarded as non site-specific. Perched water tables are common and any known depth to water may be characteristic of only very localized sites. In this light, it can be noted that depth to water is less than 50 feet in both the Missouri Valley and Platte Valley regions. Similar levels are also found along the major drainages in all six counties. Remaining depth to groundwater levels in this area are between 50 and 200 feet with very few exceptions (Figure 14).

The District currently measures the static water levels of 31 irrigation wells each spring and fall. The readings, presented in Appendix A, show depth to water as measured from natural ground. These wells are located in the Platte Valley, Missouri Valley and Upland Region areas. Specific seasonal data resulting from several years of irrigation well water level measurements, wells located in Pleistocene sand and gravel, indicate fluctuations that appear to be caused by short term weather conditions. As such, any attempt made at long range water level trends utilizing these rather short term monitoring data should be regarded as highly speculative.

As noted earlier in this report, the quality and quantity of water has been able to meet current needs. However, this does not preclude the necessity of a more extensive monitoring program in the future. The monitoring program will be discussed in more detail in Section 3.0.

### 2.2.2 Groundwater Recharge Sources

The primary source of natural recharge to the groundwater reservoir is the precipitation that falls directly on the land. However, the extent of this recharge is dependent upon several factors: the amount, frequency, and timing of precipitation events; the characteristics of the soil profile; and the topography. Assumptions based upon these characteristics must be tempered, however, by the fact that glacial till deposits in the subsurface of much of the District are above the regional water table and create perched aquifers that intercept some of the recharge.

The general soil association map presented in Figure 4 (Elder, 1969) shows the majority of the soils in the District are formed in glacial till, loess, alluvium, or a combination of these. The subsoil permeability is predominantly low. This limits recharge in that water moves slowly through the subsoil. Soil characteristics combined with the topography of this area increase total runoff amounts. High intensity rains produce a large amount of runoff which may contribute little to recharging the groundwater reservoir. Low intensity rains of longer duration would provide a greater potential for recharge since smaller amounts of runoff are produced.

A general assumption which can be made regarding natural recharge is that valley areas, principally along the Missouri, Platte and Elkhorn Rivers would have a relatively high natural recharge rate from precipitation of around 25%. The remainder of the District consisting of rolling hills and bluffs, would maintain a rather low recharge rate ranging from only 1-5% (Figure 15). Additional recharge due to runoff, permanent and intermittent streams, and various other sources appear to be negligible.

**Precipitation**

The District is located in eastern Nebraska which receives greater amounts of precipitation when compared to other areas of the state. Annual precipitation within this region averages over 28 inches, varying from a low of 26 inches in the north to approximately 29 inches in the south (Table 2). These climatological normals represent monthly total precipitation records for each year in the 30-year period, 1961-90 inclusive. Snowfall contributes to the total precipitation amounts with the heaviest contributing months being December through March. May and June generally provide the most rainfall. This rainfall is considered to be both timely and adequate for crop growth, however, annual and/or seasonal variations in these precipitation patterns are responsible for causing localized and occasionally severe droughts.

**Table 2. 30-Year Precipitation Averages (1961 - 1990), Inches**

| Month | Burt County (Tekamah) | Dakota County (Homer) | Douglas County (Waterloo) | Douglas County (Omaha) | Thurston County (Walthill) | Washington County (Blair) |
|---|---|---|---|---|---|---|
| January | 0.61 | 0.46 | 0.59 | 0.65 | 0.52 | 0.61 |
| February | 0.77 | 0.71 | 0.67 | 0.78 | 0.77 | 0.81 |
| March | 2.27 | 2.06 | 1.91 | 2.13 | 2.07 | 2.52 |
| April | 2.77 | 2.62 | 2.66 | 2.74 | 2.64 | 2.78 |
| May | 4.09 | 3.89 | 4.19 | 4.36 | 4.07 | 3.89 |
| June | 4.17 | 3.85 | 4.16 | 3.90 | 4.11 | 4.30 |
| July | 3.18 | 3.27 | 3.07 | 3.27 | 3.46 | 3.44 |
| August | 3.60 | 2.87 | 3.69 | 3.22 | 2.83 | 3.36 |
| September | 3.56 | 2.93 | 3.80 | 3.65 | 3.10 | 3.76 |
| October | 2.25 | 2.02 | 2.42 | 2.41 | 2.01 | 2.36 |
| November | 1.19 | 1.15 | 1.29 | 1.35 | 1.17 | 1.28 |
| December | 0.87 | 0.79 | 1.00 | 0.93 | 0.82 | 0.96 |
| Total Mean | 29.33 | 26.62 | 29.45 | 29.39 | 27.57 | 30.07 |

Source: University of Nebraska Lincoln, Department of Agricultural Meteorology, Nebraska State Climate Office, Institute of Agriculture and Natural Resources.

## Surface Water

The majority of streams draining the District are the result of surface runoff and tend to be short and steep with base flows in many instances so low that they cease to flow during periods of drought. This ephemeral or intermittent tendency makes them an unreliable irrigation source during critical periods of crop stress. Reflecting this unreliability is the nominal number of surface water appropriations in this area. All of the currently appropriated surface water in the P-MRNRD area (Table 3) are utilized for either irrigation

(65.3 cfs), commercial (2,449.2 cfs), domestic (177,118 Ac-Ft and 8.3 cfs), or storage (24,903.3 Ac-Ft).

In contrast to some other parts of the State, the southern part of the District has large quantities of surface water available. The major contributors are the Elkhorn, Platte and Missouri Rivers. The mouths of the Elkhorn and Platte Rivers lie within the District's boundaries. A minor contributor to surface water resources is the Papillion Creek system. Table 4 shows average discharges for several surface water sources in the P-MRNRD.

The average discharge in the Platte River is 6,534 cfs at Louisville, Nebraska, and comes primarily from three upstream sources. These sources and percent of annual flow attributable to each are the North Platte Basin (25%), the Loup Basin (41%), and the Elkhorn Basin (21%). The remaining 13% comes from the Salt Creek Basin, other unmeasured tributaries and other sources. The majority of water in the Loup system is derived from groundwater sources in the Nebraska sandhills.

The Elkhorn River has an average discharge of 1,215 cfs at Waterloo, Nebraska. The majority of water in the river comes from runoff in the basin.

The Missouri River is currently the District's largest source of surface water. This source is also the greatest surface water contributor in providing domestic water supply to area residents. Much of the flow in the Missouri River is controlled by a series of mainstream dams that regulate the flow of water in the river system. The average discharge at Omaha is 30,670 cfs.

Figure 14, which shows the generalized depth to the regional water table, also gives an indication of recharge potential to the groundwater reservoir. The recharge potential is greater along the Missouri, Platte and Elkhorn Rivers, while in the rest of the area this potential is limited due to the presence of extensive glacial till and clay deposits.

**Table 3. Surface Water Rights in the P-MRNRD**

| Stream/Creek | Usage * | Provisional Grant | County |
|---|---|---|---|
| Anderson Reservoir | SI | N/A | Washington |
| Big Papillion Creek | DO | 0.22 CFS | Douglas |
| Big Papillion Creek | IR | 7.98 CFS | Douglas |
| Blackbird Creek, South | IR | 0.38 CFS | Burt |
| Boxelder Creek | ST | 3,472 AF | Douglas |
| Cameron Reservoir | SO | N/A | Washington |
| Carr Creek | IR | 4.76 CFS | Burt |
| Combination Ditch | IR | 4.42 CFS | Burt |
| Cow Creek | IR | 0.43 CFS | Thurston |
| Davis Creek | IR | 2.3 CFS | Burt |
| Davis Creek | ST | 92.32 AF | Burt |
| Elk Creek | ? | N/A | Dakota |
| Elk Creek | IR | 4.61 CFS | Dakota |
| Elm Creek | IR | 0.47 CFS | Burt |
| Fish Creek | IR | 1.19 CFS | Washington |
| Hell Creek | ST | 145 AF | Douglas |
| Little Papillion Creek | ST | 3,910 AF | Douglas |
| Missouri River | IR | 12 CFS | Burt |
| Missouri River | CO | 1,258.58 CFS | Douglas |
| Missouri River | DO | 177,118 AF | Douglas |
| Missouri River | ST | 2,000 AF | Douglas |
| Missouri River | CO | 365.42 CFS | Sarpy |
| Missouri River | IR | 2.19 CFS | Thurston |
| Missouri River | ST | 660 AF | Thurston |
| Missouri River | CO | 825.21 CFS | Washington |
| Missouri River | DO | 7.81 CFS | Washington |
| Missouri River | IR | 0.72 CFS | Washington |
| Missouri River | ST | 2,800 AF | Washington |
| Moores Creek | ST | 220 AF | Washington |
| Mud Creek | IR | 1.62 CFS | Burt |
| Mud Creek | ST | 316.6 AF | Burt |
| New York Creek | IR | 4.02 CFS | Washington |
| Northwest Branch Big Papillion Creek | IR | 3.05 CFS | Washington |
| Northwest Branch Big Papillion Creek | ST | 18 AF | Washington |
| Omaha Creek | IR | 0.57 CFS | Thurston |
| Omaha Creek | ST | 16.84 AF | Thurston |
| Southwest Branch, Papillion Creek | ? | N/A | Washington |
| Springs | IR | 0.07 CFS | Sarpy |

**Table 3. Surface Water Rights in the P-MRNRD (Continued)**

| Stream/Creek | Usage * | Provisional Grant | | County |
|---|---|---|---|---|
| Stewart Creek | IR | 0.2 | CFS | Washington |
| Stratbucker Reservoir | SO | N/A | | Washington |
| Tekamah Creek | IR | 0.9 | CFS | Burt |
| Tekamah-Mud Creek Reservoir 41A | SO | N/A | | Burt |
| Tekamah-Mud Creek Reservoir 41A | ST | 1.8 | AF | Burt |
| Tekamah-Mud Creek Reservoir 9-A | SO | N/A | | Burt |
| Trib to Big Papillion Creek | DO | 0.22 | CFS | Douglas |
| Trib to Big Papillion Creek | ST | 2,251.56 | AF | Douglas |
| Trib to Big Papillion Creek | DO | 0.07 | CFS | Washington |
| Trib to Big Papillion Creek | IR | 1.16 | CFS | Washington |
| Trib to Big Papillion Creek | ST | 107.9 | AF | Washington |
| Trib to Boxelder Creek | ST | 80.2 | AF | Douglas |
| Trib to Elk Creek | ST | 6.8 | AF | Dakota |
| Trib to Elm Creek | ST | 68.4 | AF | Burt |
| Trib to Fish Creek | IR | 0.44 | CFS | Washington |
| Trib to Little Creek | ST | 2.44 | AF | Dakota |
| Trib to Little Papillion Creek | ST | 164 | AF | Douglas |
| Trib to Missouri River | ST | 169.9 | AF | Washington |
| Trib to Moores Creek | ST | 48.6 | AF | Washington |
| Trib to New York Creek | IR | 0.43 | CFS | Washington |
| Trib to New York Creek | ST | 46.4 | AF | Washington |
| Trib to Papillion Creek | ST | 27 | AF | Douglas |
| Trib to Randall Creek | IR | 0.81 | CFS | Thurston |
| Trib to S. Branch Papillion Creek | ST | 2,723.7 | AF | Sarpy |
| Trib to Tekamah Creek | ST | 3,028.5 | AF | Burt |
| Trib to W. Branch Papillion Creek | ST | 35.2 | AF | Douglas |
| Trib to W. Branch Papillion Creek | ST | 11 | AF | Sarpy |
| Trib to Little Papillion Creek | ST | 2,018.7 | AF | Douglas |
| Trib to Long Creek | ST | 273.86 | AF | Washington |
| Turkey Creek | ST | 86.6 | AF | Washington |
| West Papillion Creek | IR | 0.55 | CFS | Douglas |

*Usage Code:
- IR - Irrigation
- ST - Storage
- SO - Storage Only, Pump
- DO - Domestic
- CO - Commercial
- SI - Supplemental Irrigation
- ? - Unknown Code

Source: Nebraska Department of Water Resources, April 1993

**Table 4. Average Discharges for Several Surface Water Sources in the P-MRNRD**

| USGS Gage Station | River | Period of Record | Drainage Area (Sq. Mi.) | Average Discharge (cfs) | Maximum Discharge/Date (cfs) | Minimum Discharge/Date (cfs) | Avg Annual Discharge (Ac-Ft) |
|---|---|---|---|---|---|---|---|
| 06486000 | Missouri River @ Sioux City, IA | 1897-1992 | 314,600 | 28,850 (1958-1992) | 441,000 4/14/52 | 2,500 12/29/41 | 20,900,000 (1958-1992) |
| 06601000 | Omaha Creek @ Homer, NE | 1945-1992 | 168 | 37.1 | 18,100 2/19/71 | 0.1 9/16-19/48 9/9, 9/13-14/55 10/7-8/57 | 26,880 |
| 06601200 | Missouri River @ Decatur, NE | 1987-1992 | 316,200 | -- | 40,900 5/19/90 | 7,130 12/22/90 | 17,390,000 |
| 06608000 | Tekamah Creek @ Tekamah, NE | 1949-1981 | 23 | 6.2 | 6,180 6/5/63 | 0 | 4,520 |
| 06610000 | Missouri River @ Omaha, NE | 1987-1992 | 322,800 | 32,000 (1958-1992) | 396,000 4/18/52 | 2,200 1/6/37 | 23,180,000 (1958-1992) |
| 06800500 | Elkhorn River @ Waterloo, NE | 1899-1903 1911-1915 1928-1992 | 6,900 | 1,209 (1929-1992) | 100,000 6/12/44 | 50 11/12/40 | 875,700 |
| 06801000 | Platte River near Ashland | 1928-1953 1988-1992 | 84,200 | 4,954 (1989-1992) | 107,000 6/12/44 | 265 8/18/41 | 3,589,000 (1989-1992) |
| 06805500 | Platte River @ Louisville, NE | 1953-1992 | 85,800 | 6,531 (1953-1992) | 144,000 6/14/84 | 131 9/3/76 | 4,731,000 (1953-1992) |

Source: USGS Water Resources Data, Nebraska Water Year 1992; 1981

The above factors limit natural recharge and restrict the potential for artificial recharge. However, induced recharge of the groundwater reservoir from surface water in the Platte River is occuring at some locations of municipal wells in the Platte Valley Region (Figure 19). Artificial recharge is the addition of water to a groundwater reservoir as a result of man's activities, whether intentional or incidental.

On an annual basis, the groundwater reservoir appears to be recharged adequately by natural processes to meet the demands placed upon it. This is demonstrated by the 1983 and 1984 Groundwater Levels of Nebraska, prepared by the U.S. Geological Survey (USGS) and the CSD, which show that there have been no significant declines in water levels in this region of the District. It shows that the amount of water naturally discharging from the reservoir and withdrawn through wells is fully recharged under current conditions.

Seasonal fluctuations in water levels in the reservoir or in wells can be experienced. The magnitude of these fluctuations depends upon the climatic conditions which will either increase or decrease the demand for water, such as drought or periods of high rainfall.

Another type of fluctuation is associated with wells located in confined aquifers. Water in confined aquifers is under pressure and when pumping occurs, the pressure differentials cause large fluctuations in the water level. It can also affect other wells in the confined aquifer. When pumping stops, the pressures are again equalized and water levels rise rapidly to, or near, the prepumping levels.

**Supplemental Sources**

Supplemental water sources are used to augment an existing system or supply to meet current demand or to provide for new uses. Supplemental water sources are additional water supplies that are made available within a specific location by either moving it from one area to another or storing it for later usage. The area's supplemental water sources are physically limited to essentially two alternatives: 1) construction and use of surface water reservoirs; and 2) importing ground and/or surface water from other locations.

Currently, surface water reservoirs have a total maximum storage capacity of 25,270 Ac-Ft, and used primarily for flood control, recreation or other purposes. These figures include only inventory dams or those structures that have either a minimum height of 6 feet and exceed a storage capacity of 50 Ac-Ft or have a minimum height of 25 feet with greater than 15 Ac-Ft of storage. The figures do not include the numerous smaller structures or home-made farm ponds relatively common to this area.

Potential future development of significant surface water reservoirs within this area is rather limited. Economic justification for such projects, site selection and the underlying lack of a need for additional water would preclude reservoir construction indefinitely.

Similarly, the importation of surface water faces many of the limitations as reservoir construction with the additional legal hurdles and ramifications of crossing political boundaries. This legal/political issue could in itself be insurmountable.

In recent years, surface water has been used to replace groundwater as the source of water in the cities of Blair, Fort Calhoun, and Bellevue.

## 3.0 GROUNDWATER QUALITY

Traditionally, water quality is measured by the level of conventional and toxic pollutants. Most of the sources for these types of pollution come from end-of-pipe discharges, classified as point sources; but, non-point sources such as from land runoff can often become severe threats to the quality of a system. In areas of substantial agricultural production, groundwater contamination from pesticide leaching and overuse of fertilizers can occur. The most common nutrients adversely affecting water systems are nitrogen and phosphorus. Various types of human activities easily increase the concentration of these two nutrients beyond acceptable levels. Although corrective actions can be implemented for these types of pollution, prevention of contamination is far more cost-effective than attempting to correct a situation.

Several areas of groundwater quality concerns are present in the P-MRNRD. Some are naturally occurring, while others are related to potential anthropogenic problems (Engberg and Spalding, 1978, and Krueger, 1984, respectively).

Concerns considered natural relate to the composition of materials, whether consolidated or unconsolidated, which make up the groundwater reservoir. An example of this is the concentration of dissolved solids (Figure 11). Dissolved solids concentrations, (calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride and silica), within the District's principal aquifer range from 201-500 mg/l for most of this area, with locations of greater concentration, in the range of 501-1000 mg/l, in the western half of Dakota, the northwestern portion of Thurston, eastern Douglas and west central Sarpy Counties. Concentrations of dissolved solids greater than 1,000 mg/l can be found in the extreme northeast portions of Dakota, southeastern Washington and eastern Douglas Counties. The U.S. Public Health Service (1962) and the Environmental Protection Agency (EPA) (1977) have recommended a maximum for dissolved solids concentration in drinking water of 500 mg/l for aesthetic reasons.

The Missouri Valley Region experiences poor water quality based on dissolved solids. High concentrations of iron and manganese are also a problem. Four specific examples of this are documented. The Fort Calhoun area experienced poor water quality and low volumes of water from wells in the vicinity. This area is now served by a P-MRNRD rural water system. In 1982, the District was petitioned to investigate a potential source of good quality domestic water supply for the Elbow Bend/Holub's Place areas along the Missouri River south of Bellevue. Also, in 1982, the City of Blair abandoned a well field along the Missouri River and now obtains its municipal supply directly from the Missouri River. MUD also obtains water from the Missouri River rather than from wells in this area. In 1987, the District was petitioned to investigate an alternative source of water supply in eastern Burt County.

Statewide, water from the Dakota Aquifer is historically of poor quality (Engberg and Spalding, 1978). In south-central Sarpy County, poor quality water is associated with this aquifer where the groundwater reservoir is quite thin (Figure 7). Elsewhere in the southern three county area, water from wells completed in the Dakota is of good to fair quality. Many domestic, several SIDs, and a number of municipalities utilize Dakota wells.

## 3.1 Previous Groundwater Quality Activities

Human activities potentially create groundwater quality problems. Four cases of groundwater contamination have been documented in the southern three county area (Krueger, 1984). Two of these relate to hydrocarbon leakage from storage tanks, one from sulfuric acid from an industrial drainage ditch, and the fourth involved nitrate contamination from a chemical industry. However, the potential exists for more. There are over 800 industry related businesses in the P-MRNRD area using a wide variety of potentially hazardous materials and there are four (4) licensed landfill sites currently in operation. The use of pesticides and nitrogen fertilizers in agriculture also has potential for causing groundwater quality problems.

The Nebraska Department of Health (NDOH) administers the Federal (1974), state (1976) Safe Drinking Water Acts (SWDA) and its 1986 Amendments at the state level, while the County Health Departments administer them locally. These acts set quality standards for water used for human consumption, plus enforcement procedures and regulations designed to ensure compliance with the Acts by public (25 or more people) water suppliers. The owner of the public water supply is ultimately responsible for providing their customers with water that is safe to drink. Testing is required on tap water for both chemical and biological contamination on a regular basis. Municipal water systems must supply the NDOH and/or the County Health Departments samples for testing on nitrates at least annually and on other chemicals at least every three years. However, most suppliers sample and test water at least monthly. Bacteriological testing is required monthly or more frequently depending on the number of persons served by the system.

Neither NDOH or the County Health Departments currently sample and test other domestic wells on a regular basis unless they are part of a study, required by a lending institution, or if the individual requests testing be done. In addition to these duties, the County Health Departments also issues permits for wells, septic tank filter fields and land fills. The permitting process involves inspecting the site and installation of these items according to established specifications. However, once installed, there is no routine groundwater monitoring to insure that these systems are working properly.

**Cooperative Extension Service**

The University of Nebraska Cooperative Extension conducts voluntary domestic water supply testing programs in the six county area. Domestic well owners are encouraged to test annually for nitrate and bacteria. The extension agents provide the sampling bottles, instructions for sampling and assist in the interpretation of the test results. Because the program is a noncompliance program, the results are generalized by county and specific locations of wells exceeding the MCL are not provided. It should also be noted that the following sampling efforts did not include well logs, or other information regarding the wells.

Neither can it be verified if proper sampling or handling techniques were followed. Therefore, these results were not considered reliable enough to trigger the objectives of this plan.

Over 600 samples in a three year period has been collected by the East Central Extension Program Unit (EPU). This EPU includes Burt, Cuming, Washington, and Dodge Counties. Samples in Burt and Washington Counties totaled 364 in this three year period. Tables 5 and 6 summarize the 1990-92 sampling program for Burt and Washington Counties, respectively.

**Table 5. Summary of Voluntary Domestic Water Supply Data in Burt County, in Percent, (220 samples), 1990-92**

| Coliform Bacteria (coliform/100 ml) | Nitrates (mg/l) 0 | 0.1-10.0 | 10.1+ |
|---|---|---|---|
| 0 | 15% | 34 | 10 |
| 1-4 | 1 | 5 | 1 |
| 5+ | 2 | 19 | 13 |

Source: University of Nebraska, Cooperative Extension, East Central Extension Program Unit, Burt, Cuming, Dodge and Washington Counties, 1992.

**Table 6. Summary of Voluntary Domestic Water Supply Data in Washington County, in Percent, (144 samples), 1990-92**

| Coliform Bacteria (coliform/100 ml) | Nitrates (mg/l) 0 | 0.1-10.0 | 10.1+ |
|---|---|---|---|
| 0 | 31% | 21 | 3 |
| 1-4 | 1 | 7 | 3 |
| 5+ | 10 | 10 | 14 |

Source: University of Nebraska, Cooperative Extension, East Central Extension Program Unit, Burt, Cuming, Dodge and Washington Counties, 1992.

Results from the 1990-92 sampling show forty-one percent of the wells in Burt County and 45% in Washington County exceeded the drinking water standard of zero for coliform bacteria. Twenty-four percent of the Burt County wells and 20% in Washington County exceeded the recommended MCL of 10 mg/l $NO_3$-N.

Extension agents in the Metro EPU (Douglas, Lancaster, Sarpy, and Saunders Counties) conducted a private domestic well water testing campaign in early 1993. One hundred wells were tested. A summary is unavailable at this time, but may be published at a later date.

A 1985 nitrate and bacteria sampling program was conducted by the County Extension Offices at 119 domestic well sites in Dakota and Thurston Counties. Results indicated that 33% of the wells tested had a nitrate-nitrogen concentration equaling or exceeding State Health Department standard of 10.0 mg/l (Table 7). Concentrations as great as 267.7 mg/l were also noted.

**Table 7. Number, Percent and Depth of Wells Sampled for E. Coli and Nitrate in Dakota and Thurston Counties, 1985**

| Well Depth (feet) | # of Wells Tested | | Tested Wells Indicating ≥10 mg/l $NO_3$-N or ≥5 E.coli/100 ml | | | |
|---|---|---|---|---|---|---|
| | $NO_3$-N | E.Coli | ≥10 mg/l $NO_3$-N # | ≥10 mg/l $NO_3$-N % | ≥5 E.coli/100 ml # | ≥5 E.coli/100 ml % |
| 0-50 | 33 | 33 | 15 | 13 | 13 | 11 |
| 51-100 | 24 | 23 | 12 | 10 | 10 | 9 |
| 101-150 | 25 | 24 | 4 | 3 | 2 | 2 |
| 151-200 | 7 | 7 | 2 | 2 | 2 | 2 |
| 201-300 | 6 | 6 | 0 | 0 | 1 | 1 |
| 301+ | 10 | 10 | 0 | 0 | 0 | 0 |
| Unknown | 14 | 14 | 6 | 5 | 5 | 4 |
| Total | 119 | 116 | 39 | 33 | 33 | 29 |

* Three samples did not include the bacteria test. Also, one positive E. Coli test has no known well depth.

Wells sampled for coliform bacteria displayed similar results with 29% exceeding State Health Department standard of less than 5 coliform colonies per 100 ml. Bacterial counts greater than 100/100ml were not uncommon. Firm conclusions as to the contamination source and aquifer condition could not be drawn from these preliminary nitrate/bacteria data. Well depth, construction and site location all appear to have influenced these results.

Water samples were also collected in 1979 from 41 domestic, stock and irrigation wells in Burt County and tested for nitrate-nitrogen concentrations. Results of this study indicate nitrate-nitrogen concentrations to be in violation of minimum State Health Department standards in 16% of the domestic wells. Stock and irrigation wells were all within limitations.

Conclusions drawn from this 1979 study were that it appeared from the dispersed nature of the locations with high nitrate concentrations in the domestic wells were the result of point-source contamination. This point-source would ordinarily be limited to the contamination of a specific well location rather than a large volume of the regional aquifer. Well construction and site selection were considered to be the major contributors to these high nitrate levels.

**Nebraska Department of Health**

The NDOH prepared a report on municipal water system tests in 1984. Table 8 summarized selected results from the NDOH publication. These data show that there does not appear to be a nitrate-nitrogen problem in water used for municipal purposes. This does not, however, preclude the existence of isolated areas of high nitrate concentrations which may exist. A study by the CSD in October, 1980, does indicate areas of high nitrate-nitrogen concentrations. The Omaha-Douglas County Health Department has also reported high nitrate-nitrogen concentrations in the area surrounding the Village of Bennington.

Other potential groundwater contaminants, e.g. volatile synthetic organic chemicals (VOCs), trihalomethanes, pesticides, petroleum distillates, trace metals, etc., have either not been found in municipal water systems or in such minute quantities as not to be considered a serious health risk (Traces of carbon tetrachloride--up to 2.1 mg/l--have been noted in the Hubbard community water system in 1982). Currently, there is no corresponding data available for domestic water supplies.

**Table 8. General Inorganic Chemical Analysis, Municipal Water Systems in Dakota, Thurston and Burt Counties of the P-MRNRD**

| Municipality | Sample Well I.D.# | Date | pH | Ts | Fe | Mn | F | Alk | Hard | Ca | $NO_3$ | Cl | $SO_4$ | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arlington | 39-1(2) | 6-74 | 7.3 | 681 | 1.3 | 0.6 | 0.46 | 328 | 146 | 128 | 0.0 | 18 | 164 | 50 |
| | 65-1(3) | 6-74 | 7.5 | 500 | 0.7 | 0.1 | 0.50 | 324 | 340 | 96 | 0.0 | 8 | 98 | 44 |
| | F | 6-74 | 7.5 | 612 | 0.2 | 0.1 | 0.46 | 320 | 412 | 128 | 0.2 | 19 | 193 | 52 |
| Bellevue | F | 11-77 | 8.2 | 490 | 0.0 | 0.1 | 0.90 | 328 | 312 | 77 | 0.6 | 2 | 80 | 26 |
| | D | 5-75 | 8.7 | 298 | 0.0 | 0.0 | 1.14 | 208 | 192 | 34 | 0.2 | 12 | 44 | 17 |
| | 58-1(3) | 6-73 | 7.7 | 632 | 15.0 | 1.4 | 0.33 | 516 | 556 | 197 | 1.2 | 8 | 63 | 30 |
| | 62-1(4) | 6-73 | 7.5 | 694 | 11.5 | 1.0 | 0.33 | 500 | 572 | 120 | 0.0 | 10 | 100 | 38 |
| | 62-2(5) | 6-73 | 7.5 | 552 | 6.5 | 0.4 | 0.33 | 496 | 480 | 115 | 0.8 | 8 | 53 | 39 |
| | 65-1(6) | 6-73 | 7.8 | 430 | 8.0 | 0.2 | 0.35 | 388 | 296 | 106 | 0.8 | 8 | 33 | 23 |
| | 67-1(1) | 6-73 | 7.6 | 476 | 10.0 | 0.2 | 0.32 | 408 | 428 | 107 | 0.4 | 6 | 45 | 20 |
| | 67-2(2) | 6-73 | 7.8 | 456 | 11.0 | 0.4 | 0.35 | 356 | 376 | 91 | 0.8 | 8 | 35 | 20 |
| Bennington | 53-1(2) | 5-74 | 7.5 | 426 | 2.2 | 0.0 | 0.35 | 312 | 328 | 88 | 0.2 | 4 | 31 | 19 |
| | 68-1(3) | 5-74 | 7.4 | 432 | 0.7 | 0.2 | 0.37 | 320 | 312 | 90 | 0.2 | 2 | 31 | 20 |
| | 70-1(4) | 5-74 | 7.3 | 422 | 0.4 | 0.2 | 0.41 | 321 | 308 | 90 | 0.0 | 6 | 33 | 19 |
| Blair | D | 1-77 | 8.1 | 684 | 2.2 | 0.1 | 1.10 | 308 | 396 | 62 | 0.2 | 12 | 260 | 72 |
| | 56-2(7) | 1-77 | 7.8 | 1294 | 12.0 | 0.6 | 0.46 | 640 | 800 | 179 | 0.0 | 2 | 480 | 122 |
| | 56-3(8) | 5-77 | 7.1 | 1903 | 23.0 | 0.7 | 0.50 | 680 | 960 | 215 | 0.0 | 4 | 865 | 144 |
| | 59-1(3) | 1-77 | 7.3 | 494 | 2.0 | 0.8 | 0.43 | 404 | 400 | 108 | 0.0 | 18 | 31 | 18 |
| | 66-1(13) | 5-77 | 6.9 | 400 | 6.5 | 0.7 | 0.41 | 384 | 320 | 94 | 0.0 | 0 | 7 | 12 |
| | 66-2(9) | 1-77 | 7.4 | 704 | 36.0 | 1.2 | 0.42 | 632 | 548 | 160 | 0.2 | 6 | 11 | 27 |
| | 66-3(10) | 1-77 | 7.5 | 376 | 3.7 | 1.0 | 0.44 | 276 | 324 | 84 | 0.0 | 14 | 50 | 11 |
| | 67-1(11) | 1-77 | 7.7 | 314 | 3.0 | 1.1 | 0.41 | 324 | 280 | 61 | 0.0 | 0 | 0 | 14 |
| | 67-2(12) | 5-77 | 7.1 | 416 | 2.1 | 1.0 | 0.48 | 340 | 348 | 93 | 0.0 | 18 | 38 | 9 |
| | 68-1(14) | 5-77 | 6.9 | 544 | 5.4 | 1.6 | 0.41 | 412 | 464 | 120 | 0.0 | 26 | 53 | 6 |
| | 75-1 | 1-77 | 7.8 | 556 | 8.5 | 2.2 | 0.69 | 276 | 412 | 90 | 0.0 | 56 | 102 | 21 |
| | 77-1 | 10-77 | 7.8 | 410 | 0.2 | 1.6 | 0.40 | 360 | 332 | 88 | 0.4 | 0 | 17 | 18 |
| Craig | IF | 11-76 | 7.9 | 898 | 2.1 | 0.0 | 0.95 | 340 | 544 | 160 | 0.8 | 44 | 420 | 41 |
| | 40-1 | 11-76 | 7.5 | 1308 | 1.9 | 0.2 | 1.30 | 328 | 660 | 196 | 0.0 | 66 | 635 | 61 |
| Dakota City[1] | D | 2-76 | 7.6 | 788 | 0.2 | 0.2 | 0.42 | 560 | 680 | 122 | 0.8 | 14 | 134 | 20 |
| | 56-1(1) | 2-76 | 7.3 | 326 | 7.1 | 0.8 | 0.46 | 576 | 608 | 165 | 0.0 | 12 | 135 | 21 |
| | 58-1(2) | 2-76 | 7.8 | 626 | 11.0 | 0.4 | 0.32 | 480 | 508 | 123 | 0.0 | 8 | 119 | 17 |
| | N/A | 10-84 | --- | --- | --- | --- | --- | --- | --- | --- | 0.9 | --- | --- | 56 |
| Decatur | D | 7-75 | 7.4 | 494 | 0.0 | 0.0 | 0.39 | 372 | 428 | 112 | 0.0 | 10 | 80 | 11 |
| | 66-1,72-1(c) | 7-75 | 7.2 | 546 | 0.3 | 0.2 | 0.38 | 392 | 440 | 125 | 0.0 | 8 | 108 | 13 |
| | N/A | 10-84 | --- | --- | --- | --- | --- | --- | --- | --- | 0.4 | -- | --- | 28 |
| Elkhorn | 51-1(2) | 8-76 | 7.5 | 336 | 0.0 | 0.0 | 0.25 | 280 | 272 | 78 | 0.6 | 0 | 9 | 7 |
| | 57-1(3) | 8-76 | 7.2 | 424 | 0.0 | 0.0 | 0.25 | 300 | 336 | 91 | 1.8 | 2 | 25 | 6 |
| | 71-1(1) | 8-76 | 7.6 | 360 | 0.0 | 0.0 | 0.26 | 272 | 256 | 82 | 0.6 | 4 | 21 | 5 |
| | 73-1(4) | 8-76 | 7.3 | 404 | 0.0 | 0.0 | 0.27 | 292 | 300 | 90 | 2.4 | 6 | 13 | 5 |

**Table 8. General Inorganic Chemical Analysis, Municipal Water Systems in Dakota, Thurston and Burt Counties of the P-MRNRD (Continued)**

| Municipality | Sample Well I.D.# | Date | pH | Ts | Fe | Mn | F | Alk | Hard | Ca | $NO_3$ | Cl | $SO_4$ | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Emerson | 72-1(4) | 4-83 | 7.65 | 716 | 6.5 | 1.0 | 0.28 | 364 | 512 | 157 | 7.6 | 18 | 130 | 37 |
| | 80-1(5) | 4-83 | 7.40 | 618 | 0.2 | 0.7 | 0.30 | 372 | 460 | 138 | 0.1 | 10 | 97 | 32 |
| | F | 4-83 | 7.50 | 606 | 0.1 | Nil | 0.32 | 372 | 476 | 133 | 0.1 | 6 | 97 | 31 |
| | N/A | 10-84 | --- | --- | --- | --- | --- | --- | --- | --- | 0.3 | --- | --- | 33 |
| Gretna | 64-1(2) | 9-76 | 7.8 | 380 | 1.5 | 0.1 | 0.23 | 308 | 332 | 93 | 0.0 | 2 | 15 | 8 |
| | 70-1(4) | 9-76 | 7.4 | 374 | 1.8 | 0.1 | 0.26 | 304 | 288 | 88 | 0.0 | 2 | 15 | 10 |
| | 72-1(1) | 9-76 | 7.9 | 368 | 0.0 | 0.0 | 0.26 | 304 | 288 | 88 | 0.6 | 4 | 23 | 15 |
| Herman | 66-1 | 5-74 | 7.3 | 434 | 0.2 | 1.0 | 0.48 | 344 | 336 | 94 | 0.0 | 0 | 22 | 19 |
| Homer | 56-1(2) | 2-76 | 7.3 | 416 | 4.5 | 0.7 | 0.48 | 400 | 436 | 134 | 0.0 | 0 | 60 | 7 |
| | 67-1(3) | 2-76 | 7.4 | 446 | 1.4 | 0.5 | 0.54 | 320 | 372 | 102 | 0.8 | 0 | 60 | 8 |
| | 79-1 | 3-80 | 7.0 | 440 | 0.5 | 0.4 | 1.28 | 368 | 392 | 118 | 0.4 | 14 | 122 | 22 |
| Hubbard | 56-1,74-1(c) | 1-75 | 7.5 | 420 | 0.0 | 0.0 | 0.43 | 336 | 388 | 110 | 5.8 | 4 | 44 | 16 |
| | N/A | 11-84 | --- | --- | --- | --- | --- | --- | --- | --- | 6.4 | --- | --- | 198 |
| Jackson | 48-1(2) | 3-76 | 7.0 | 550 | 0.3 | 0.0 | 1.15 | 368 | 420 | 122 | 0.0 | 16 | 128 | 36 |
| | 78-1 | 3-79 | 7.3 | 774 | 1.3 | 0.1 | 1.19 | 348 | 504 | 152 | 0.0 | 14 | 225 | 40 |
| | N/A | 11-84 | --- | --- | --- | --- | --- | --- | --- | --- | 0.1 | --- | --- | 50 |
| Kennard | 09-1(1) | 1-75 | 7.5 | 500 | 1.2 | 0.7 | 0.52 | 424 | 396 | 112 | 0.0 | 0 | 8 | 27 |
| | 65-1(2) | 1-75 | 7.6 | 420 | 5.6 | 1.2 | 0.34 | 316 | 324 | 85 | 0.0 | 2 | 8 | 16 |
| Lyons | 51-1(1) | 1-77 | 7.5 | 436 | 1.0 | 1.5 | 0.34 | 320 | 340 | 83 | 0.0 | 12 | 25 | 21 |
| | 76-1(2) | 8-76 | 7.6 | 396 | 1.3 | 1.5 | 0.33 | 352 | 380 | 104 | 0.0 | 4 | 27 | 16 |
| | 78-1 | 7-78 | 7.2 | 480 | 1.8 | 1.8 | 0.31 | 316 | 412 | 90 | 0.0 | 14 | 32 | 12 |
| | F | 1-77 | 8.0 | 380 | 0.2 | 0.1 | 0.32 | 308 | 312 | 88 | 0.2 | 16 | 23 | 21 |
| Macy | F | 1-76 | 7.2 | 960 | 1.1 | 0.2 | 1.67 | 292 | 508 | 154 | 0.0 | 56 | 355 | 58 |
| | D | 1-78 | 7.8 | 1320 | 0.4 | 0.0 | 1.70 | 280 | 516 | 157 | 0.0 | 54 | 330 | 47 |
| Oakland | 54-1 | 9-76 | 7.6 | 676 | 14.0 | 0.8 | 0.67 | 356 | 436 | 130 | 0.0 | 26 | 185 | 38 |
| | 58-1 | 9-76 | 7.5 | 778 | 0.8 | 0.2 | 1.14 | 340 | 456 | 144 | 0.0 | 38 | 245 | 47 |
| | 78-1 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Papillion | 46-1 | 6-76 | 8.0 | 280 | 0.0 | 0.0 | 0.28 | 260 | 260 | 69 | 3.7 | 10 | 13 | 11 |
| | 46-2 | 6-76 | 8.3 | 280 | 0.0 | 0.0 | 0.27 | 236 | 256 | 67 | 2.6 | 8 | 15 | 9 |
| | 56-1 | 6-76 | 7.5 | 400 | 0.0 | 0.0 | 0.22 | 324 | 352 | 101 | 1.8 | 8 | 47 | 12 |
| | 62-1 | 6-76 | 7.8 | 300 | 0.0 | 0.0 | 0.22 | 240 | 252 | 66 | 0.8 | 8 | 44 | 11 |
| | 67-1 | 6-76 | 8.2 | 344 | 0.0 | 0.0 | 0.41 | 236 | 284 | 78 | 2.3 | 20 | 47 | 13 |
| Pender[2] | 50-1 | 12-74 | 7.5 | 512 | 0.0 | 0.0 | 0.46 | 312 | 352 | 98 | 3.0 | 2 | 49 | 16 |
| | 52-1 | 12-74 | 7.4 | 458 | 4.9 | 0.4 | 0.33 | 300 | 308 | 91 | 0.0 | 4 | 20 | 14 |
| | 64-1 | 12-74 | 7.7 | 518 | 0.0 | 0.0 | 0.48 | 324 | 360 | 99 | 3.4 | 4 | 56 | 17 |
| | 78-1 | 1-78 | 7.6 | 420 | 0.0 | 0.0 | 0.26 | 316 | 344 | 98 | 3.2 | 2 | 47 | 14 |

**Table 8. General Inorganic Chemical Analysis, Municipal Water Systems in Dakota, Thurston and Burt Counties of the P-MRNRD (Continued)**

| Municipality | Sample Well I.D.# | Date | pH | Ts | Fe | Mn | F | Alk | Hard | Ca | $NO_3$ | Cl | $SO_4$ | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rosalie | 10-1,18-1(c) | 3-76 | 7.1 | 344 | 0.0 | 0.0 | 0.31 | 324 | 304 | 88 | 1.0 | 0 | 13 | 7 |
| Springfield | 41-1 | 6-73 | 8.5 | 334 | 1.1 | 0.0 | 0.28 | 280 | 292 | 78 | 1.8 | 10 | 12 | 24 |
| | 49-1 | 6-76 | 8.4 | 300 | 0.7 | 0.0 | 0.27 | 256 | 248 | 69 | 0.8 | 2 | 11 | 11 |
| | 70-1 | 6-76 | 7.3 | 264 | 0.0 | 0.0 | 0.31 | 236 | 248 | 67 | 1.2 | 0 | 8 | 12 |
| South Sioux City | 56-1 | 2-77 | 7.7 | 1106 | 5.0 | 0.7 | 0.41 | 584 | 780 | 206 | 0.0 | 144 | 225 | 69 |
| | 65-1 | 12-78 | 7.0 | 1146 | 1.6 | 0.6 | 0.59 | 360 | 880 | 202 | 0.2 | 44 | 505 | 90 |
| | 73-1 | 12-78 | 6.9 | 1000 | 1.0 | 0.4 | 0.58 | 668 | 760 | 179 | 0.0 | 20 | 280 | 76 |
| | 78-1 | 12-78 | 7.2 | 1032 | 0.1 | 0.1 | 0.51 | 336 | 575 | 152 | 0.4 | 32 | 400 | 81 |
| Tekamah | 49-1(3) | 10-81 | 7.6 | 488 | 0.0 | 0.0 | 0.38 | 300 | 388 | 106 | 5.8 | 22 | 83 | 14 |
| | 55-1(1) | 10-81 | 7.7 | 388 | 0.0 | 0.0 | 0.42 | 328 | 344 | 91 | 1.8 | 6 | 25 | 10 |
| | 59-1(2) | 10-81 | 7.8 | 344 | 0.0 | 0.0 | 0.42 | 316 | 324 | 96 | 2.0 | 6 | 19 | 10 |
| | 59-2(4) | 10-81 | 7.7 | 570 | 0.0 | 0.0 | 0.50 | 324 | 408 | 109 | 2.4 | 12 | 98 | 22 |
| | 75-1(5) | 10-81 | 7.9 | 488 | 0.0 | 0.0 | 0.39 | 344 | 400 | 110 | 13.6 | 18 | 39 | 12 |
| Thurston | 54-1,64-1(c) | 5-76 | 8.0 | 586 | 1.5 | 1.3 | 0.34 | 468 | 404 | 131 | 1.2 | 2 | 99 | 16 |
| Valley | 35-1 | 8-77 | 7.7 | 362 | 0.0 | 0.6 | 0.30 | 184 | 232 | 70 | 1.7 | 16 | 69 | 19 |
| | 55-1 | 8-77 | 7.7 | 282 | 0.0 | 0.7 | 0.36 | 184 | 176 | 53 | 0.4 | 10 | 63 | 17 |
| | 40-1 | 8-77 | 7.6 | 348 | 0.5 | 0.2 | 0.29 | 184 | 220 | 69 | 0.0 | 16 | 65 | 18 |
| Walthill | 47-1,61-1(c) | 7-74 | 7.5 | 556 | 1.3 | 0.1 | 0.91 | 316 | 404 | 125 | 0.6 | 24 | 138 | 29 |
| Waterloo | 50-1 | 6-78 | 7.9 | 344 | 0.9 | 1.0 | 0.38 | 228 | 276 | 85 | 0.0 | 14 | 59 | 15 |
| | 69-1 | 6-78 | 7.9 | 308 | 1.3 | 0.8 | 0.51 | 204 | 240 | 75 | 0.0 | 8 | 57 | 11 |
| Winnebago | 56-1 | 1-74 | 7.3 | 1142 | 3.7 | 0.2 | 1.14 | 2.64 | 720 | 195 | 0.0 | 94 | 208 | 123 |
| | 72-1 | 5-76 | 7.8 | 1496 | 0.0 | 0.0 | 2.79 | 1.80 | 880 | 243 | 0.0 | 104 | 310 | 1 |
| | 79-1 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

Key

pH: Negative logarithm of hydrogen ion concentration. 7.0=neutral
Ts: Total solids in mg/l. Recommended limit for drinking water is 500 mg/l.
Fe: Ion in mg/l. Recommended limit for drinking water is 0.3 mg/l.
Mn: Manganese in mg/l. Recommended limit for drinking water is 0.05 mg/l.
F: Fluoride in mg/l. Recommended limit for drinking water is 1.8 mg/l.
Alk: Total alkalinity in mg/l calcium carbonate.
Hard: Total hardness in mg/l calcium carbonate. Water with greater than 400 mg/l calcium carbonate is considered extremely hard.
Ca: Calcium in mg/l.
$NO_3$: Nitrate as mg/l $NO_3$-N. Recommended limit for drinking water is 10.0 mg/l.
Cl: Chloride in mg/l.
$SO_4$: Sulfate in mg/l. Recommended limit for drinking water is 250 mg/l.
Na: Sodium in mg/l. Recommended limit for drinking water is 500 mg/l.

[1] Supplies water to P-MRNRD's Rural Water #1 System.
[2] Supplies water to P-MRNRD's Rural Water #2 System.

On an annual basis, the NDOH perform tests on public drinking water supplies for volatile synthetic organic compounds (VOC's). Appendix B is a copy of the 1992 compliance monitoring samples for VOC's in the P-MRNRD.

Existing water quality databases on the public drinking water supplies from the NDOH have been processed. Three databases are available: 1) heavy metals or inorganic compounds; 2) nitrate/sodium monitoring of community water systems; and 3) nitrate monitoring of non-community water systems. These database reports are provided in Appendix C, D, and E. The nitrate/sodium reports present the maximum, minimum and mean for several nitrate and sodium samples. Upon request from the Nebraska Natural Resources Commission (NRC), a detailed report of each individual test can be obtained.

**Masters Theses on Bedrock Aquifers**

In 1987, Jeffery W. Pipes, completed his thesis on the hydrogeologic framework of the Paleozoic aquifers in Washington, Douglas, and Sarpy Counties. Borehole geophysical techniques were utilized to characterize the area's hydrogeology. Four wells located at the Henry Doorly Zoo, Omaha Cold Storage, Missouri River WWTP and the Harriet Anderson residence, were tested in 1986-87. All four wells exceeded the Maximum Concentration Level (MCL) of 0.3 mg/l for iron, with the well at Harriet Anderson detecting 6.09 mg/l. Pipes generalized that the chemistry of composite water samples indicated that the water was generally of acceptable quality for some uses. The relatively high total dissolved solids (TDS) and sulfate concentrations could limit its desirability for domestic uses.

In 1987, Mark O'Conner completed his thesis on the hydrogeology of the Dakota Formation in Douglas, Sarpy, and Washington Counties. Sixty-four (64) samples were collected from twenty-five (25) wells in August and November of 1986 and in March, 1987. Nitrate-nitrogen concentrations were low with only two wells exceeding 10 mg/l. TDS recommended limits of 500 mg/l were exceeded in three wells. O'Conner summarized that total dissolved solids increased rapidly toward the north, and TDS may exceed recommended levels in parts of Washington County. Iron exceeded 0.3 mg/l in five wells and manganese exceed 0.05 mg/l in 7 wells.

**National Pesticide Survey**

In early 1988, EPA began a National Pesticide Survey (NPS) to determine the nature and extent of pesticide contamination in drinking water wells. Ninety counties were sampled nationwide; in Nebraska, Burt County was selected for this survey. Thirteen wells were sampled in the county during the fall of 1989. None of the wells sampled had detectable levels of pesticides. The EPA survey showed that 54% of the wells (7/13) had detectable levels of nitrates and ranged from less than 1 mg/l to 123 mg/l. Four of the thirteen wells (31%) exceeded the safe drinking water standard of 10 mg/l.

**University of Nebraska Water Center**

In 1990, a final report was issued by Roy F. Spalding on the water quality in the Lower Platte River Basin with an emphasis on agrichemicals. His investigation included an assessment of groundwater contamination vulnerability utilizing the DRASTIC model; the distribution of agrichemicals in the groundwater via sampling; agrichemical contamination of surface water via sampling; and the distribution of uranium in the Platte River and its tributaries.

DRASTIC, prepared by the National Water Well Association for EPA in 1987, is a method to evaluate the potential for groundwater contamination based on the hydrogeologic settings. It was used as a screening tool to compare the relative potential for pollution in different areas. A DRASITC Index or the pollution potential for seven hydrogeologic factors was found for Washington, Douglas and Sarpy Counties. Results indicated the regions with the greatest potential for groundwater contamination lie between the Platte and Elkhorn Rivers from Fremont south to their confluence and along the Platte near its confluence with the Missouri River.

Spalding sampled eighty wells in 1988-89 in the P-MRNRD counties of Washington, Douglas and Sarpy (Table 9). Seventy-one of these wells were also sampled in 1978-79 during the National Uranium Resource Evaluation (NURE) study. Four wells (P-38, P-15, P-18 and P-44) had nitrate-nitrogen concentration exceeding the MCL of 10 mg/l $NO_3$-N. Only two irrigation wells in the sampled area had sufficient concentrations of $NO_3$-N for nitrogen isotope analysis. Both samples were highly fractionated and had $\delta^{15}N$ values of +32 and +15.4%.

Detectable levels of atrazine (>0.02mg/l) were measured in 5 irrigation wells (P-60, P-62, P-59, P-63 and P-64). Three of these wells are located between the Elkhorn and Platte Rivers in Douglas County, and the other two wells are located near the left overbank of the Elkhorn River.

In 1990, the Water Center at the University of Nebraska published a compilation of pesticide and nitrate data in Nebraska's groundwater. Data was provided by the USGS, NDOH, NDEQ, NRD's, CSD and the Lincoln Lancaster County Health Department. Pesticide data prior to January 1, 1989 and nitrate data from the five years from 1984 through 1988 were used. Samples were analyzed for a series of pesticides. Only one domestic well site located in north central Washington County had atrazine concentrations between 0.51 - 1.00 mg/l. Nitrates have been detected in several domestic wells in the P-MRNRD. Figure 16 shows the distribution of the nitrate-nitrogen concentrations above 7.4 mg/l. The majority of detections were in Thurston and Washington Counties.

## 3.2 Groundwater Quality Monitoring

In July 1991, the P-MRNRD and the United States Geologic Survey (USGS) entered into an agreement to sample, evaluate, process and present groundwater quality characteristics of numerous wells and suggest future monitoring programs. The USGS evaluated the hydrogeology of the P-MRNRD using data from well logs, test holes, and other available sources.

**Table 9. Water Quality Samples in the Lower Platte River Basin, 1979, 1988**

| Location | Sample | Type | Depth (feet) | $NO_3$-N 1979 | (mgl) 1988 | Atrazine $\delta^{15}N$ (%) | (μg/l) |
|---|---|---|---|---|---|---|---|
| 12N-11E-4CD | P-29 | H | 117 | 23 | 9.1 | | |
| 12N-11E-11BC | P-44M | H | 42 | 1.7 | 0.9 | | |
| 12N-11E-18CD | P-45M | H | 36 | 0.4 | < 0.1 | | |
| 13N-10E-13DC | P-28 | H | 160 | - - | 0.3 | | |
| 13N-10E-14CD | P-27 | H | 162 | 0.42 | 0.3 | | |
| 13N-10E-21B | P-60 | I | - - | - - | 0.1 | - - | 0.06 |
| 13N-11E-2BA | P-24 | H | 144 | 2.2 | 1.9 | | |
| 13N-11E-22AA | P-25 | H | 126 | 5.9 | 3.6 | | |
| 13N-11E-24DD | P-43M | H | 144 | 1.7 | 0.9 | | |
| 13N-12E-21CD | P-42M | H | 60 | 4.7 | 4.0 | | |
| 13N-12E-24AC | P-40M | H | - - | - - | 4.1 | | |
| 13N-12E-24DB | P-41M | H | 132 | 1.2 | 1.0 | | |
| 13N-13E-29DC | - - | M | 58 | - - | 0.7 | | |
| 13N-13E-30CC | - - | M | 55 | - - | 0.2 | | |
| 13N-13E-30CC | - - | M | 52 | - - | 0.2 | | |
| 13N-13E-30CD | - - | M | 53 | - - | 0.9 | | |
| 13N-13E-30CD | - - | M | 53 | - - | < 0.1 | | |
| 13N-13E-30DD | - - | M | 49 | - - | 1.6 | | |
| 13N-14E-30CD | P-20 | IN | 87 | - - | 0.3 | | |
| 14N-10E-5DC | P-47M | H | 15 | 0.81 | 1.8 | | |
| 14N-10E-11AB | P-30 | H | 207 | 1.9 | 1.9 | | |
| 14N-10E-28AB | P-61 | I | - - | - - | 0.3 | - - | < 0.02 |
| 14N-10E-33C | P-58 | I | - - | - - | 7.8 | +32 | < 0.02 |
| 14N-10E-33CD | P-3 | I | 100 | - - | 0.9 | | |
| 14N-10E-34CA | P-26 | H | 108 | 0.5 | 0.2 | | |
| 14N-10E-35AA | P-46M | H | 198 | 0.88 | 0.8 | | |
| 14N-11E-4CD | P-38 | H | 27 | 20 | 16 | | |
| 14N-11E-33BC | P-48 | H | 220 | - - | - - | | |
| 14N-12E-15BC | P-22 | H | 225 | 0.15 | - - | | |
| 14N-12E-28AD | P-23 | H | 72 | < 0.02 | 0.2 | | |
| 14N-12E-36DA | P-21 | H | 135 | 0.77 | 0.9 | | |
| 15N-10E-7DD | P-39 | H | 60 | - - | | | |
| 15N-10E-7DD | P-48M | H | 72 | 3.3 | 0.2 | | |
| 15N-10E-14AA | P-62 | I | 45 | 0.09 | 7.9 | +15.4 | 0.02 |
| 15N-10E-32D | P-59 | I | - - | - - | 0.4 | | 0.1 |
| 15N-11E-20AD | P-43 | H | 99 | 2.4 | < 0.1 | | |
| 16N-9E-1DB | P-49K | H | 27 | < 0.02 | < 0.1 | | |
| 16N-9E-5CA | P-2 | H | 54 | < 0.02 | 0.3 | | |
| 16N-9E-8DC | P-1 | H | 18 | < 0.02 | 0.2 | | |
| 16N-9E-16AA | P-63 | I | - - | - - | 0.7 | - - | 0.44 |
| 16N-9E-27AD | P-31 | H | 54 | < 0.02 | < 0.1 | | |
| 16N-10E-13DC | P-33 | H | 285 | < 0.02 | < 0.1 | | |
| 16N-10E-19A | P-64 | I | - - | - - | < 0.1 | - - | 0.03 |
| 16N-10E-33BC | P-32 | I | 33 | 0.2 | < 0.1 | | |
| 16N-10E-36DD | P-40 | H | 162 | 0.11 | < 0.1 | | |

**Table 9. Water Quality Samples in the Lower Platte River Basin, 1979, 1988 (Continued)**

| Location | Sample | Type | Depth (feet) | $NO_3$-N 1979 | (mgl) 1988 | Atrazine $\delta^{15}N$ (%) | ($\mu$g/l) |
|---|---|---|---|---|---|---|---|
| 16N-11E-9AA | P-36 | H | 97 | - - | < 0.1 | | |
| 16N-11E-12BA | P-37 | H | - - | - - | 3.6 | | |
| 16N-11E-25CC | P-35 | H | 135 | 0.2 | 0.4 | | |
| 16N-11E-32DD | P-34 | H | 132 | < 0.02 | < 0.1 | | |
| 16N-12E-4CD | P-41 | H | 228 | 7.0 | 6.8 | | |
| 16N-12E-12AA | P-42 | H | 66 | 0.37 | 0.8 | | |
| 16N-12E-29BB | P-51 | H | 24 | 7.6 | 1.8 | | |
| 16N-12E-36BA | P-52 | H | 141 | 6.6 | 3.8 | | |
| 17N-9E-1AD | P-47 | H | 183 | < 0.02 | < 0.1 | | |
| 17N-10E-1AA | P-54 | H | 150 | < 0.02 | < 0.1 | | |
| 17N-10E-17AA | P-53 | H | 27 | 13 | < 0.1 | | |
| 17N-11E-2DA | P-17 | H | 270 | < 0.02 | < 0.1 | | |
| 17N-11E-21BB | P-15 | H | 30 | 11 | 18 | | |
| 17N-12E-18BA | P-46 | H | 333 | < 0.02 | < 0.1 | | |
| 17N-12E-21BD | P-18 | H | 87 | 10 | 27 | | |
| 17N-12E-24AD | P-19 | H | 102 | < 0.02 | < 0.1 | | |
| 18N-9E-2DD | P-14 | H | 294 | < 0.02 | < 0.1 | | |
| 18N-9E-17B | P-13 | I | 45 | 0.25 | 0.1 | | |
| 18N-10E-17B | P-45 | H | 36 | 15 | 8.4 | | |
| 18N-10E-4AC | P-10 | H | 39 | 6.5 | 8.2 | | |
| 18N-10E-33BC | P-11 | H | 45 | < 0.02 | < 0.1 | | |
| 18N-11E-9AC | P-55 | H | 60 | 0.1 | 0.1 | | |
| 18N-11E-28CC | P-16 | H | 171 | < 0.02 | < 0.1 | | |
| 19N-9E-13CA | P-8 | H | 273 | < 0.02 | < 0.1 | | |
| 19N-9E-21AA | P-7 | H | 183 | < 0.02 | < 0.1 | | |
| 19N-10E-21BD | P-12 | H | 21 | 4.5 | 3.2 | | |
| 19N-10E-24AD | P-56 | H | 111 | 4.6 | 1.3 | | |
| 19N-11E-13BB | P-5 | H | 90 | - - | < 0.1 | | |
| 19N-11E-21BD | P-6 | H | 86 | < 0.02 | < 0.1 | | |
| 19N-11E-36DA | P-4 | H | 72 | < 0.02 | < 0.1 | | |
| 20N-9E-33AA | P-9 | H | 96 | 9.8 | 9.8 | | |
| 20N-9E-36BB | P-44 | H | 42 | 68 | 123 | | |
| 20N-10E-22DB | P-57 | H | 333 | < 0.02 | < 0.1 | | |
| 20N-11E-34A | P-66 | I | 90 | 0.02 | 0.2 | - - | < 0.02 |
| 20N-11E-34D | P-67 | I | - - | - - | < 0.1 | - - | < 0.02 |

Source: Roy F. Spalding; "Water Quality in the Lower Platte River Basin with Emphasis on Agrichemicals", July 5, 1990.

### 3.2.1 Hydrogeology

Based on geologic and hydrologic information available from the USGS and the CSD, and in published and unpublished reports the hydrogeologic units in the P-MRNRD were divided into three main aquifers or aquifer systems: 1) the saturated permeable limestones and sandstones in the lower Paleozoic deposits (Cambrian through Mississippian); 2) the saturated sandstones in the Dakota Formation; and 3) the saturated sand and gravel beds in the Quaternary deposits.

The data indicates saturated lower Paleozoic deposits underlie the District at depths ranging from 500 feet to 1,000 feet. Wells completed in the lower Paleozoic rocks were a common source of water in the Omaha area for industrial use from approximately 1870 to 1970. At the present time, the majority of water for industrial use is supplied by MUD. There are no registered industrial or municipal wells in the P-MRNRD that are completed in the lower Paleozoic rocks. Therefore, existing water-quality data will be used to describe the inorganic geochemistry of the water in the lower Paleozoic rocks. Because of the variety of methods that were used to complete the wells in the lower Paleozoic rocks, it is probable that only a generalized characterization of water from the lower Paleozoic deposits can be made.

Saturated sandstones in the Dakota Formation are commonly used as a source of water for domestic, municipal, and irrigation supplies throughout those parts of the P-MRNRD where the formation is present. Because the sands, silts, and clays that comprise the Dakota Formation are of fluvial origin, large and abrupt horizontal and vertical lithologic variations are common. The Dakota directly underlies the Quaternary deposits in many parts of the P-MRNRD, and it has been a common well drilling practice to complete wells in both the Quaternary deposits and the Dakota when an adequate supply of water cannot be solely obtained from the Quaternary deposits. Therefore, sampling from wells screened only in the Dakota is essential for evaluating the quality of water from the Dakota Formation.

Quaternary deposits of alluvial, eolian, and glacial origin underlie the entire area of the P-MRNRD, except for small local areas where the bedrock crops out. The lithologic composition of the Quaternary deposits, which is variable both vertically and horizontally, ranges from relatively impermeable clays and silts to permeable sand and gravel deposits. It is probable that some domestic and stock wells in the P-MRNRD are completed in silt deposits, but yields from these wells would be very low and the deposits should not be considered a commonly used or significant source of water. Therefore, only wells that were completed in coarse-grained deposits were sampled. Because of the potential variations in water yield and water quality that can be caused by differences in lithology, sources of recharge, and land use, the Quaternary coarse-grained deposits were subdivided into four areally restricted aquifers. These aquifers are composed of the Quaternary alluvial deposits along the Missouri River valley, the Quaternary alluvial deposits along the Platte River valley, the Quaternary alluvial deposits along the Elkhorn River valley, and the Quaternary alluvial deposits that occur in the upland parts of the P-MRNRD.

**Missouri River Valley Quaternary Alluvial Deposits**

Areally, the Missouri River Valley Quaternary alluvial deposits are the coarse-grained Quaternary deposits that occur beneath the floodplain and low terraces along the Missouri River. The coarse-grained deposits generally contain more sand than gravel, and are often intermixed and interbedded with silts and clays. Most of the deposits are the result of flood flows in the Missouri River and organic material is common, especially in the fine grained deposits. As a result, in some areas, the water in the deposits occurs under reducing conditions. The deposits are recharged by infiltration of precipitation through the relatively permeable soils, infiltration of run-off from the adjacent upland areas, and from the Missouri River when the river stage is greater than ground-water levels. Much of the land is used for crop production and irrigation with groundwater is common.

## Platte River Valley Quaternary Alluvial Deposits

The Platte River Valley Quaternary alluvial deposits occur beneath the floodplain and low terraces along the Platte River valley from below the mouth of the Elkhorn River to the mouth of the Platte River. Most of the deposits are very permeable coarse-grained sands and gravels. Clays and silts usually occur only in the thin surficial deposits. Most of the recharge to the deposits is from the Platte River because the valley is very narrow and recharge from infiltration of runoff and precipitation has a limited area in which to occur. Only a small amount of area is used for crop production.

## Elkhorn River Valley Quaternary Alluvial Deposits

Areally, the Elkhorn River Valley Quaternary alluvial deposits are those that occur beneath the floodplain and low terraces along the Elkhorn River valley. In northwestern Sarpy County and western Douglas County the area includes the lowlands between the Platte and Elkhorn Rivers. Most of these deposits are permeable coarse-grained sands and gravels, but clays and silts are intermixed and interbedded with the sands and gravels. Recharge to the deposits is from infiltration of the precipitation that falls on the area, from infiltration of runoff from upland areas, and from the adjacent Elkhorn and Platte Rivers when river stage is higher than ground-water levels. Much of the area is used for irrigated crop production.

## Upland Area Quaternary Alluvial Deposits

The Upland Area Quaternary alluvial deposits are the coarse-grained alluvial deposits that occur beneath the thick silt and clay beds that blanket the upland parts of the P-MRNRD. Available data are not adequate to define and delineate the occurrence and distribution of these sand and gravel deposits. The available data, however, indicates large variations in the thickness and the vertical and horizontal distribution of these coarse-grained deposits. Almost all recharge to these deposits is from the infiltration of precipitation. Most of the land is used for dryland crop production and grazing.

### 3.2.2 Selected Monitoring Wells

A total of 61 wells (Figure 17 and Table 10) were selected using a stratified-random approach. These selected wells were to be properly constructed, have driller's logs, and be completed in a representative portion of one of the aquifer systems. The selected wells were sampled from June through August 1992 by the USGS. All water samples were tested for nitrate at the US Geological Survey National Water Quality Laboratory (NWQL) and screened for pesticides using immuno-assay kits. Nineteen samples were quantitatively analyzed for pesticides and industrial organic contaminants using gas chromatography. Forty two samples were analyzed for major ions, and trace elements. Forty samples were analyzed for radon and eleven for radium. Appendix F contains preliminary test results from the USGS sampling program.

**Table 10. USGS Groundwater Quality Monitoring, P-MRNRD**

| Well ID | Registration Number | Latitude/Longitude | Township & Range | Sample Type[1] |
|---|---|---|---|---|
| Dakota Wells | | | | |
| D1 | G-28320 | 4227580962439 | T29NR9E28ABAB | 2 |
| D2 | ----- | 4218480963718 | T27NR7E16CABD | 2 |
| D3 | ----- | 4213500962713 | T26NR9E18ABCB | 2 |
| D4 | ----- | 4205190962732 | T24NR9E6BBAB | 1 |
| D5 | G-28229 | 4146450961343 | T21NR11E19BBCD | 1 |
| D6 | G-6474 | 4141090961511 | T20NR10E23DDAA | 2 |
| D7 | G-56246 | 4132400962133 | T18NR9E12CAAC | 1 |
| D8 | G-39163 | 4120500961431 | T16NR10E24ABCA | 2 |
| D9 | G-39628 | 4117190961356 | T15NR11E7BBDC | 2 |
| D10 | G-70449 | 4111250960930 | T14NR11E15AAAA | 2 |
| D11 | G-27986 | 4108240961419 | T14NR10E36ADCC | 2 |
| D12 | G-44441 | 4108180960012 | T14NR13E31CBBC | 2 |
| D13 | G-34831 | 4105030960738 | T13NR11E24ACBD | 1 |
| Platte Wells | | | | |
| P1 | G-41584 | 4105350961745 | T13NR10E16DACC | 2 |
| P2 | G-58437 | 4104110961757 | T13NR10E28ACBA | 2 |
| P3 | G-70437 | 4104070960327 | T13NR12E27BCDA | 2 |
| P4 | G-55914 | 4104050961821 | T13NR10E28BCDD | 2 |
| P5 | G-27296 | 4103270960618 | T13NR12E31ABDA | 2 |
| P6 | A-10538F | 4103340955957 | T13NR13E31BABB | 2 |

**Table 10. USGS Groundwater Quality Monitoring, P-MRNRD (Continued)**

| Well ID | Registration Number | Latitude/Longitude | Township & Range | Sample Type[1] |
|---|---|---|---|---|
| P7 | A-10538H | 4103320955947 | T13NR13E31BAAC | 2 |
| P8 | A-10538K | 4103370955937 | T13NR13E30DCCC | 1 |
| P9 | A-10538GG | 4103430955808 | T13NR13E29DDCA | 1 |
| P10 | G-30872 | 4103340955259 | T13NR14E31BACD | 2 |
| Upland Wells | | | | |
| U1 | ------ | 4213170962624 | T26NR9E17CCAA | 1 |
| U2 | ----- | 4208480962451 | T25NR9E9DCCC | 2 |
| U3 | G-58097 | 4208250962924 | T25NR8E11DCCC | 1 |
| U4 | G-60170 | 4130530962054 | T18NR9E24DADA | 1 |
| U5 | G-56161 | 4127520962041 | T17NR10E7BBAC | 2 |
| U6 | G-66250A | 4126290960530 | T17NR12E17CACA | 1 |
| U7 | G-72636 | 4126360961832 | T17NR10E16CBBB | 1 |
| U8 | G-57211 | 4124540961226 | T17NR11E29CABA | 2 |
| U9 | ----- | 4120180960845 | T16NR11E23DCBA | 2 |
| U10 | G-13675 | 4119140960224 | T16NR12E35BBAB | 1 |
| U11 | G-51724 | 4106510961348 | T13NR11E7BCO | 2 |
| U12 | G-35768 | 4105250960816 | T13NR10E14CDDA | 1 |
| U13 | G-47649 | 4103500960810 | T13NR11E25CBCD | 2 |
| Missouri River Alluvium Wells | | | | |
| M1 | G-62679 | 4225240962507 | T28NR9E4CDBC | 2 |
| M2 | G-51696 | 4223010962622 | T28NR9E20CBDD | 2 |
| M3 | G-56985 | 4220330962747 | T27NR8E1DAAA | 1 |
| M4 | G-31915 | 4207460961957 | T25NR10E19ABDD | 2 |
| M5 | G-57365 | 4157100961157 | T23NR11E20DBAB | 2 |
| M6 | G-35076 | 4146010961300 | T21NR11E30AO | 2 |
| M7 | G-55113 | 4142000961338 | T20NR11E18CDBC | 1 |
| M8 | G-28115 | 4140200961306 | T20NR11E30DCAA | 2 |
| M9 | G-57975 | 4127350955701 | T17NR13E9ACDA | 2 |
| M10 | ----- | 4125590960056 | T17NR12E24BACC | 2 |
| M11 | G-71101 | 4118550955519 | T16NR13E35BDCB | 2 |
| M12 | G-39162 | 4106300955413 | T13NR13E12CBDA | 2 |
| M13 | G-70289 | 4104570955235 | T13NR14E19AAAB | 1 |
| Elkhorn River Alluvium Wells | | | | |
| E1 | A-13909A | 4123330962648 | T16NR9E6AABA | 2 |
| E2 | A-13909B | 4123120962616 | T16NR9E5BDCA | 1 |
| E3 | G-71860 | 4122300962145 | T16NR9E12BO | 1 |
| E4 | G-71406 | 4119370962137 | T16NR9E25CAAC | 1 |
| E5 | G-74586 | 4117550961628 | T16NR10E34DDDC | 2 |
| E6 | G-71076 | 4117410961733 | T15NR10E4DDAA | 2 |
| E7 | G-56172 | 4117230962116 | T15NR9E12ABAC | 2 |
| E8 | G-70952 | 4116560962004 | T15NR10E7DACB | 2 |
| E9 | G-50989 | 4116200961640 | T15NR10E15ACAD | 2 |
| E10 | G-67158A | 4115070961548 | T15NR10E23CADD | 2 |
| E11 | G-69883 | 4112580952058 | T14NR9E1AADD | 2 |
| E12 | G-56513 | 4110140961741 | T14NR10E21ADBD | 2 |

[1]Sample Type 1 = Trace elements not tested.
2 = Trace elements tested.

Source: US Geological Survey, preliminary data, 1993.

Each aquifer system had approximately an equal amount of sampled wells. Thirteen wells were sampled in each of the Dakota, Upland and Missouri River alluvium aquifer systems. Ten wells were sampled in the Platte River Valley and 12 wells were selected in the Elkhorn River aquifer systems.

The well numbering system used by the USGS in Nebraska is based on the land subdivisions within the U.S. Bureau of Land Management's survey of Nebraska. The numeral preceding N (north) indicates the township, the numeral preceding E (east) or W (west) indicated the range, and the numeral preceding the terminal letters indicates the section in which the well is located. The terminal letters denote, respectively, the quarter section, the quarter-quarter section, the quarter-quarter-quarter section, and the quarter-quarter-quarter-quarter section. The letters are assigned in a counterclockwise direction beginning with "A" in the northeast corner of each subdivision. If two or more wells are located within the same subdivision, they are distinguished by adding a sequential digit to the well number. An "O" after an A, B, C, or D, indicates that the well is located in the approximate center of the subdivision. For example, a second well located within the SW¼ of the SE¼ of the NW¼ of the SE¼, Section 21, T23N, R58W would be assigned 23N-58W-21DBDC2.

In addition, each well receives a USGS identification number of which the first six digits represent the latitude and the next seven digits represent the longitude, both in degrees, minutes, and seconds. The final two digits are sequence number beginning with "01".

The water quality data was processed through the USGS WATSTORE System and analyzed. Statistical methodology will include: summary statistics for each of the aquifers, contingency table analyses, and the Kruskal-Wallis and Mann-Whitney tests for comparing constituent medians among different aquifers.

The chance of contamination of the water-quality samples, including bottles and preservatives, was reduced through field quality-control measures. The quality-assurance program at the NWQL includes participation in the USGS and U.S. Environmental Protection Agency interlaboratory evaluations and submission of blind standard reference water sample to the NWQL sample stream (Friedman and Fishman, 1982; Jones, 1987). In addition, cation-anion balances were calculated for each complete analysis to ensure internally consistent data.

Quality control and quality assurance for the gas-chromatographic analyses included use of standard matrix spikes, blanks, and internal blanks and data evaluation.

### 3.2.3 Additional Proposed Monitoring Wells

In addition to sampling the 61 wells, the USGS selected 31 additional wells (Figure 17 and Table 11) to sample at a later date. These additional wells will provide a base sampling program of 92 wells.

The final report, to be published at a later date by the USGS, will present groundwater quality characteristics, any exceedances of public drinking water criteria, and suggest future monitoring programs.

**Table 11. Proposed Groundwater Quality Wells for Future Sampling, P-MRNRD**

| Well ID | Registration Number | Township & Range | Owner |
|---|---|---|---|
| Dakota Wells | | | |
| D21 | ------- | T25NR9E11DBBC | Village of Walthill |
| D22 | G-64689 | T21NR11E7BA | Leo Tobin Farms Inc. |
| D23 | G-66192 | T21NR10E16DD | Wayne Hansen |
| D24 | G-63778 | T19NR9E14CB | Terry Rasmussen |
| D25 | G-70559 | T15NR11E11DD | Steve Jacobs |
| D26 | G-67158 | T15NR10E23CD | Riverside Lakes SID #177 |
| Missouri River Alluvium Wells | | | |
| M21 | G-57993 | T29NR8E21AO | Bernard George |
| M22 | G-45243 | T28NR7E1DC | Wayne Knudsen |
| M23 | G-72940 | T27NR9E27AO | Clarence Olson |
| M24 | G-40732 | T22NR11E16AD | Neal White |

**Table 11. Proposed Groundwater Quality Wells for Future Sampling, P-MRNRD (Continued)**

| Well ID | Registration Number | Township & Range | Owner |
|---|---|---|---|
| M25 | G-23733 | T21NR11E11DB | Lloyd Williamson |
| M26 | G-70527 | T21NR12E16BC | Lois Blodgett |
| M27 | G-31477 | T19NR12E7BC | Ned Tyson |
| M28 | G-71263 | T19NR11E23AC | Neale Farm Partners |
| M29 | G-57053 | T18NR12E5BB | Fort Calhoun Stone Company |
| Upland Wells | | | |
| U21 | G-23567 | T26NR7E24BD | Gladys Stout |
| U22 | G-46360 | T23NR10E8DC | Harold Sears |
| U23 | G-59182 | T17NR9E1AA | Boyd Gieselman |
| U24 | G-40782 | T17NR11E14ABSID | #1 Donald Caspar |
| U25 | G-71467 | T17NR10E18O | Dunkley Dairy |
| U26 | A-10587B | T14NR12E26DB | City of Papillion |
| Platte Wells | | | |
| P21 | G-56278 | T13NR10E4DD | Ron True, tenant |
| P22 | G-52563 | T13NR10E21BO | Floyd Bundy |
| P23 | G-55915 | T13NR10E29AB | Melvin Bundy |
| P24 | G-05692 | T12NR11E16BD | Duane Doud |
| P25 | G-55657 | T12NR11E2AA | Daniel Schram |
| Elkhorn River Alluvium Wells | | | |
| E21 | G-58481 | T16NR9E3AO | Donald Anderson |
| E22 | G-35436 | T16NR10E27BD | Clark Noyes |
| E23 | G-54894 | T16NR10E32DA | Janice Allen |
| E24 | G-66702 | T15NR10E28AB | William Patterson |
| E25 | G-50878 | T15NR10E34BC | Donald Walvoord |

Source: US Geological Survey, provisional data, 1993.

## 3.3 Suitability Characteristics

### 3.3.1 Domestic

Groundwater quality standards must adhere to the requirements of the Nebraska Department of Environmental Quality's Title 118. All groundwater of the State are classified based on existing and potential water use. Groundwater currently or proposed as either a public or private water supply are subject to the numerical standard listed in Title 118. These numerical standards, maximum contaminant levels, are listed in Appendix F.

### 3.3.2 Irrigation

The concentration and composition of dissolved constituents in a water determines its suitability for irrigation. According to the US Department of Agriculture's, Agricultural Handbook No. 60, four characteristics determine quality: 1) total concentration of soluble salts; 2) relative proportion of sodium to other cations; 3) concentration of boron or other elements that may be toxic; and 4) the bicarbonate concentrations as related to the concentration of calcium plus magnesium. Table 12 summarizes the chemical quality necessary for irrigation.

**Table 12. Water Quality Suitability for Irrigation**

| Constituent | Concentration | Comments |
|---|---|---|
| Dissolved Solids | <500mg/l | No adverse effects |
| | 500-1000 mg/l | No adverse effects, if leaching or adequate drainage exists |
| | > 1500 mg/l | Harmful to most crops |
| Sodium Plus Potassium | SAR > 10 | Medium to high sodium hazard, harmful to plants and soil. Sodium adsorption ratio (SAR) is a ratio of the ion concentrations of sodium, calcium and magnesium. |
| Sulfate | > 500 mg/l | Does not directly affect crops, contributes to high salinity |
| Silica | | Not known to be harmful to animals or plants |
| Boron | > 330 μg/l | Unsafe for crops |

Source: Engberg US Geological Survey and Spalding, Conservation and Survey Division, Groundwater Quality Atlas of Nebraska, Resource Atlas No. 3, 1978.

### 3.3.3 Livestock

Water is an essential nutrient for livestock production, and toxic levels of various substances in water for livestock and poultry can be deadly. Limited information is available on experimentally determined toxic levels. The National Academy of Sciences cautions applying information in the literature to practical situations. There are problems assigning toxic levels to waterborne substances and no single concentration can be accepted as dangerous in all situations. Toxic substances affect different species of animals. Table 13 presents concentrations of potentially toxic substances in drinking water for livestock and poultry. Many factors affecting toxicity make it difficult to determine harmful concentration levels in drinking water. These values are general and should not be used as guidelines for water suitability for livestock and poultry.

**Table 13. Recommended Limits of Concentration of Some Potentially Toxic Substances in Drinking Water for Livestock and Poultry**

| Constituent | Safe Upper Limit of Concentration (mg/l) |
|---|---|
| Arsenic | 0.2 |
| Cadmium | 0.05 |
| Chromium | 1.0 |
| Cobalt | 1.0 |
| Copper | 0.5 |
| Fluoride | 2.0 |
| Lead | 0.1 |
| Mercury | 0.01 |
| Nickel | 1.0 |
| Nitrate-N | 100.0 |
| Nitrite-N | 10.0 |
| Salinity | 1,000 |
| Vanadium | 0.1 |
| Zinc | 25.0 |

Source: National Academy of Sciences, Nutrients and Toxic Substances in Water for Livestock and Poulty, 1974

The National Research Council generalizes on water requirements for various animal species. Concentrations of 2% sodium chloride in water is considered toxic for dairy cattle. Also, some of the elements that cause hardness could be toxic if present in high concentrations. Sulfates and nitrates in water can be harmful to swine. Seerley. et. al (1965) considered it unlikely that sufficient nitrite would be formed and consumed in water alone to cause toxicity if the initial level of nitrate did not exceed 300 mg/l of $NO_3$-N.

## 3.4 Needs and Data Deficiencies

The USGS has sampled or identified 92 wells for a groundwater monitoring program. Once the baseline has been identified, sampling of the selected wells on a periodic basis can begin, to ensure that the existing conditions of the groundwater reservoir are maintained.

The monitoring objective, presented in Section 7.0, may be re-evaluated to fit the problems that may arise.

## 4.0 LAND USE AND CONTAMINATION SOURCE INVENTORY

An important element to understanding existing and/or potential sources of groundwater contamination is recognizing the interrelationship between land use and contamination sources.

### 4.1 Land Use

The P-MRNRD covers 1,146,895 acres, in which the majority of the land is non-irrigated cropland. Table 14 summarizes the land use distribution in the District and Figure 18 shows the agricultural and urban land uses. The majority of the urban population resides in the Omaha metropolitan area. Irrigated cropland is found in the eastern portions of Dakota, Washington and Burt Counties along the Missouri River and in western portions of Douglas, Washington and Sarpy Counties bordering the Platte and Elkhorn Rivers.

**Table 14. Land Use Distribution in the P-MRNRD**

| Category | Acres | Usage % |
|---|---|---|
| Non-Irrigated Cropland | 736,700 | 64.2% |
| Irrigated Cropland: | | |
| Sprinkler Irrigation | 38,455 | 3.4% |
| Surface Irrigation | 38,050 | 3.3% |
| Pasture | 73,580 | 6.4% |
| Rangeland | 11,430 | 1.0% |
| Forest Land | 79,665 | 6.9% |
| Other Farmland | 25,745 | 2.2% |
| Barren Land | 5,390 | 0.5% |
| Urban | 118,840 | 10.4% |
| Water | 19,040 | 1.7% |
| Totals | 1,146,895 | 100% |

Source: Nebraska Natural Resource Commission, SCS, Nebraska Resource Census, 1983-84.

Tables 15 and 16 are a land use summary for portions of Douglas and Sarpy Counties. Residential lands includes single and multi family residents. Industrial areas include industrial, transportation, communications and utility facilities. Commercial land use includes retail service and non-public office buildings. Public land uses are schools, hospitals, churches, fire/police, public and civic buildings, etc. Open spaces include golf courses, athletic fields, water and waterways, etc. Major arterial right-of-way, agricultural lands and vacant lots are included in the Other category.

**Table 15. Land Use Summary for Portions of Douglas and Sarpy Counties[1], (1970 - 1990) in Acres**

| | Residential | Industrial | Commercial | Public | Open Spaces | Other | Total |
|---|---|---|---|---|---|---|---|
| 1970 | 37,870 | 11,200 | 3,820 | 7,800 | 14,280 | 203,490 | 278,460 |
| 1975 | 42,810 | 11,930 | 4,590 | 8,380 | 15,170 | 195,580 | 278,460 |
| 1980 | 47,250 | 12,560 | 5,220 | 8,830 | 16,030 | 188,570 | 278,460 |
| 1985 | 50,070 | 12,870 | 5,900 | 9,090 | 17,700 | 182,830 | 278,460 |
| 1990 | 53,860 | 12,840 | 7,060 | 9,280 | 19,180 | 176,240 | 278,460 |

[1] Includes area bounded on the east by the Missouri River, on the west by 216th Street, on the north by the Washington/Douglas County border and on the south by a line extending 10 miles south of Harrison Street and the Platte River.

Source: Metropolitan Area Planning Agency, December, 1991.

**Table 16. Land Use Summary for Portions of Douglas and Sarpy Counties[1], (1970 - 1990) in Percent**

| | Residential | Industrial | Commercial | Public | Open Spaces | Other |
|---|---|---|---|---|---|---|
| 1970 | 14% | 4% | 1% | 3% | 5% | 73% |
| 1975 | 15% | 4% | 2% | 3% | 5% | 70% |
| 1980 | 17% | 5% | 2% | 3% | 6% | 68% |
| 1985 | 18% | 5% | 2% | 3% | 6% | 66% |
| 1990 | 19% | 5% | 3% | 3% | 7% | 63% |

[1] Includes area bounded on the east by the Missouri River, on the west by 216th Street, on the north by the Washington/Douglas County border and on the south by a line extending 10 miles south of Harrison Street and the Platte River.

Source: Metropolitan Area Planning Agency, December, 1991.

Tables 15 and 16 illustrate the classic inverse relationship between expansion of population centers and reduction of agricultural acreage. During the twenty year period the "Other" land use category registered the most significant change as shown by the 10% decrease. This is offset by the predicted increases in the remaining categories, most notably the 5% rise in residential use. The pattern for land use within the District, over the next decade, will show a continual conversion of agricultural lands to other utilities such as residential, industrial and commercial.

## 4.2 Contamination Source Inventory

Nonpoint and point sources interact with the physical environment and have the ability to contaminate the groundwater reservoir. Identifying these sources and developing controls can reduce the threat of groundwater contamination.

### 4.2.1 Nonpoint Source Inventory

Nonpoint sources are defined as indiscernible, diffuse and indistinct conveyance from which pollutants are or may be discharged. Nonpoint sources, which are difficult to assess quantitatively and control, include inputs from agrichemicals, storm water runoff, erosion, groundwater, and biological sources such as animal feedlots. Nonpoint source pollution has the potential to significantly impact groundwater quality. Nonpoint source problems in Nebraska include agrichemicals, soil erosion and sedimentation, livestock wastes and urban stormwater. No current data is available to quantify the pollutants from these sources.

Residential agrichemicals are applied in urbanized areas. The greatest potential for nonpoint sources lie in Douglas and Sarpy Counties, where the greatest concentration of the populous reside.

Erosion and sedimentation are natural geologic phenomena. Land development activities, however, have initiated severe, highly undesirable, and damaging alterations in the natural process by accelerating the erosion/sedimentation process.

Sedimentation is a rural and urban problem. Existing NRD programs assist landowners in the implementation of conservation plans for the construction of soil and water conservation practices. These include terraces, diversions, waterways and erosion control structures to help prevent soil erosion, reduce downstream sedimentation and control nonpoint pollution. Urban programs provide technical assistance to landowners and developers on conservation related problems, erosion, and flooding programs in urban areas.

The Nebraska Sediment and Erosion Control Act of 1986 allows landowners to petition and request the NRD assistance to control sediment and erosion. This act applies to agricultural lands and excludes commercial, industrial and urban lands.

The Clean Water Act and its amendments have established water quality standards, discharge limitations, and permit goals for point discharge limitations, and permit goals for point discharges. The current application requirements require a permit for storm water discharge associated with construction operations that result in the disturbance of five acres of total land. An erosion and sedimentation control plan is necessary to obtain a permit. A soil erosion and sedimentation control manual has been developed by the City of Omaha and the District to assist developers in obtaining a permit for storm water associated with construction activity in the Omaha Metropolitan area.

Nonpoint sources of pollution from agricultural lands are currently unregulated. The Clean Water Act statutorily exempted agricultural storm water and irrigation return flows.

### 4.2.2 Point Source Inventory

In addition to the authority delegated to the NRDs in the GWMPA, statutory authorities in the area of groundwater quality have been assigned to the NDEQ and NDOH.

In 1971, the Nebraska Environmental Protection Act established NDEQ and entrusted it with the responsibility of protecting and improving environmental quality in the state. NDEQ monitors the land, water, and air for changes in environmental quality. They also issue permits and periodically inspect industries engaged in activities that could affect environmental quality. Long range strategies are also developed, such as the Nebraska Groundwater Quality Protection Strategy (NGQPS).

NDEQ's current monitoring programs involve predominantly point sources (e.g. industrial and municipal discharge points and solid waste disposal sites) for compliance purposes. They do not systematically sample and/or monitor wells for groundwater quality in other areas of the District which might relate to non-point sources (e.g. pesticides and nitrogen fertilizers). The NGQPS identifies the need to monitor potential contamination sources such as:

1) Spills and leaks of hazardous materials from commercial storage facilities,
2) Agricultural chemical usage, primarily nitrogen fertilizers and pesticides,
3) Waste treatment and disposal areas,
4) Abandoned or poorly constructed wells and test holes,
5) Hazardous material storage, usage, and disposal at industrial facilities, and
6) Spills or leaks of hazardous materials along transportation corridors.

A major focus of the Federal Clear Water Act (CWA) is controlling "point source" pollution. In this Act, a "point source" is defined as "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel. . .from which pollutants are or may be discharged". 33 U.S.C. Section 1362(14). This Act empowered EPA or an authorized state agency to conduct programs relevant to the requirements of the CWA. Within the State of Nebraska, the NDEQ administers such programs; their requirements not only overlay the federal regulatory structure, but are often more stringent. Table 17 summarizes the number of regulatory point permits issued by NDEQ and EPA for various communities in the P-MRNRD. Reports are generated to assist in the performance of environmental assessments and audits and to identify potential sources of concern, several of which are included in the Appendices.

**Table 17. Summary of Point Sources by Community in the P-MRNRD**

| County | Community | RCRIS[1] | UST[2] | CERCLIS[3] | NPDES[4] | Haz Waste[5] | WWTF/WWTP[6] |
|---|---|---|---|---|---|---|---|
| Washington | Arlington | 2 | 2 | - | 2 | 1 | 1 |
| Sarpy | Bellevue | 28 | 44 | 3 | 6 | 12 | 6 |
| Douglas | Bennington | 3 | 2 | - | 1 | 1 | 1 |
| Washington | Blair | 12 | 14 | - | 6 | 3 | 6 |
| Douglas | Boys Town | - | 2 | - | - | - | 1 |
| Dakota | Dakota City | 3 | 5 | - | 4 | 2 | 4 |
| Burt | Decatur | - | 1 | - | 1 | - | 1 |
| Douglas | Elkhorn | 10 | 3 | - | 7 | 5 | 6 |
| Washington | Fort Calhoun | 5 | 2 | 2 | 3 | 2 | 3 |
| Sarpy | Gretna | 4 | 2 | - | 3 | - | 3 |
| Washington | Herman | 1 | - | - | - | - | 1 |
| Dakota | Homer | - | - | - | 1 | - | 1 |
| Dakota | Hubbard | - | - | 1 | 1 | - | 1 |
| Dakota | Irvington | - | 5 | - | - | - | - |
| Dakota | Jackson | - | 1 | 1 | 1 | - | 1 |
| Washington | Kennard | 1 | 1 | - | 2 | - | 2 |
| Sarpy | La Platte | 3 | 1 | - | 2 | 2 | 3 |
| Sarpy | La Vista | 4 | 1 | - | - | 1 | - |
| Burt | Lyons | 3 | 5 | - | 3 | - | 2 |
| Thurston | Macy | - | - | - | 1 | - | 1 |
| Douglas | Millard | - | - | - | 1 | - | 1 |
| Sarpy | Offutt AFB | 2 | 1 | - | - | 1 | - |
| Douglas | Omaha | 674 | 488 | 64 | 60 | 227 | 42[7] |
| Sarpy | Papillion | 13 | 10 | 1 | 3 | 2 | 1 |
| Douglas | Ralston | 7 | 10 | - | 1 | 2 | 1 |
| Dakota | South Sioux City | 19 | 8 | - | 6 | 2 | 6 |
| Sarpy | Springfield | 3 | 3 | - | 6 | - | 3 |
| Burt | Tekamah | 4 | 6 | - | 2 | - | 1 |
| Douglas | Valley | 6 | 8 | - | 3 | 2 | 3 |
| Thurston | Walthill | 5 | 2 | - | 2 | - | 1 |
| Washington | Washington | - | 1 | - | - | - | - |
| Douglas | Waterloo | 4 | 1 | 1 | 4 | 1 | 3 |
| Thurston | Winnebago | 2 | - | - | 2 | - | - |
| | Douglas Cty (SID) | - | - | - | 4 | - | 3 |
| | Sarpy Cty (SID) | - | - | - | 5 | - | 5 |
| Totals | | 817 | 629 | 73 | 144 | 266 | 114 |

1 Resource Conservation and Recovery Act, NDEQ, March 15, 1993.
2 Underground Storage Tanks, December 9, 1992.
3 Comprehensive Environmental Response, Compensation and Liability Information System.
4 National Pollution Discharge Elimination System, March 11, 1992.
5 Hazardous Waste Admin. Inventory, May 28, 1991.
6 Waste Water Treatment Facility or Waste Water Treatment Plant, Permit Compliance System, NDEQ, December 31, 1992.
7 Includes MUD Platte River WTP in Sarpy County.

## RCRA

The Resource Conservation and Recovery Act (RCRA) is a federal statute designed to protect groundwater from contamination through releases of hazardous substances. It sets up a "cradle-to-grave" system for tracking wastes from their generation, through transportation, to treatment, storage or disposal. To comply with RCRA, businesses that generate, store or transport hazardous waste are required to register their activities with the EPA. RCRIS is a list of businesses that have complied under RCRA. There are 817 RCRA registrations in the P-MRNRD. Appendix H is a copy of the RCRA notifiers list.

## Title III

The Emergency Planning and Community Right-to-Know Act, or Title III, lists businesses that use, store, or release hazardous substances as part of the normal business operations. Title III was established to provide necessary information to emergency response teams when preparing for incidents involving hazardous substances and to appraise the public of any hazardous materials being used in their community. Appendix I lists Title III, Section 313, Toxic Chemical Release Inventory for the P-MRNRD.

## Underground Storage Tanks

NDEQ prepares Underground Storage Tanks (UST) lists and CERCLIS inventory reports that identify known contamination sites. UST identifies all sites with reported underground storage tanks releases, of which there are 629 sites in the P-MRNRD. CERCLIS is an acronym for the Comprehensive Environmental Response and Liability Information System. Seventy-three CERCLIS sites in the P-MRNRD were identified in a March 1992 report. Appendix J is a listing of CERCLIS sites.

**NPDES**

The National Pollution Discharge Elimination System (NPDES) requires all persons discharging pollutants from a point source into any waters of the state to apply and obtain a permit for this activity State requirements for NPDES permitting are specified under Title 119-NDEQ. One hundred and forty four operations were listed as having NPDES and Nebraska Pretreatment Program (NPP) permits. Waste water treatment facilities, water treatment facilities, and sanitary improvement districts comprise the majority of the permitees. Appendix K lists the NPDES permittes.

**Hazardous Waste Inventory**

The EPA report for Hazardous Waste Administrative Inventory lists 266 facilities in the P-MRNRD. Agricultural livestock facilities in the six county area total 72, of which approximately 75% of these feedlots require some type of control. Five waste facilities are also listed in the All Ag Facilities report provided in Appendix L.

**Wellhead Protection Area**

NDEQ has delineated Well Head Protection Areas. These protected areas are assigned remedial action class (RAC) categories, according to Title 118. These categories form a pollution occurrence ranking scheme based on the groundwater usage. The City of Omaha has been designated as RAC-1 and requires a 500 foot radius around all private drinking water supply wells.

**Solid Waste Facilities**

Solid waste facilities are licensed by NDEQ. In February, 1988, Homer was identified as having an unlicensed waste facility and scheduled for additional study. In a January 1990, Waste Recovery Section Project Inventory, the status of several solid waste facilities were outlined. Municipal landfills in the process of closing in 1990 were identified in Douglas County on State Street and Sarpy County on Cedar Island Road. Dumps located in Wathill and Homer were closed and verified.

Four active licensed landfills exist in the P-MRNRD. Table 18 summarizes the capacity of these facilities. Three compost operations were identified in a November 3, 1992 report. They include operations in Omaha, Bennington and Papillion. The Omaha operation handles livestock pen waste, while the other two sites handle yard waste.

**Table 18. Active Licensed Landfills in the P-MRNRD**

| County | Landfill Name | Tons Disposed (1990) | Expected Life | Active (ac) | Design (ac) | Closed (ac) |
|---|---|---|---|---|---|---|
| Dakota | Gill, L.P. | 59,000 | 80 - 100 | 13 | 170 | 8 |
| Douglas | Waste Mgmt | 480,000 | 18 | 25 | 90 | 8 |
| Sarpy | Sarpy Co. Landfill #2 | 109,000 | 18 | 4 | 74 | 0 |
| Washington | Blair Disposal Area | 7,200 | 15 - 18 | 15 | 30 | 0 |

Source: SCS Engineers

## Chemigation

Chemigation through center pivot irrigation systems are regulated through the Nebraska Chemigation Act of 1986. This Act requires center pivot owners who chemigate to take measures to prevent chemicals from contaminating the groundwater supply. NRDs were assigned the responsibility to inspect these systems, verify safety precautions, and issue permits for chemigation. There are 33 active permits in the P-MRNRD, which are listed in Appendix M.

### Private Septic Systems

A common private septic system consists of a septic tank and soil absorption field. Liquid waste flows from the tank to the soil absorption field where it is purified as it filters through the soil. Soil type is crucial to this process since only certain types of soil can properly purify the effluent. A soil with large pores allows the effluent to move quickly and does not hold it long enough for complete purification before it encounters the groundwater. Where soils are too tight, septic systems will not drain adequately and may break down or cause nuisance conditions. Pollutants of concern from septic systems are nitrates, bacteria, viruses, and hazardous chemicals.

There are presently no statistics which summarize the number of septic systems in the P-MRNRD. However, areas of concern include residential development surrounding lakes formed from sand and gravel operations, predominantly along the Platte and Elkhorn Rivers. Soils in these areas are coarse, and depth to groundwater is relatively shallow, making the potential for contamination greater than in upland sites.

The location of septic systems relative to drinking water wells is important in determining contamination potential. Where local hydrogeology is suitable, and wells and septic systems are properly constructed, contamination from private septic systems should be minimal.

## 4.3 Needs and Data Deficiencies

The land use data provided by the NRC databank primarily focused on agricultural lands. All urban lands were grouped together. In urbanized areas, where sources of containments may need to be further defined, a more detailed map may be necessary.

Improperly abandoned wells provide a mechanism to introduce containments into the groundwater. The Nebraska Department of Health, Title 178, Chapter 12 - Regulations

Governing Water Well Construction, Pump Installation and Water Well Abandonment Standards - defines the proper procedure to abandon a well. A record of permanently discontinued wells or water wells in which the use has been accomplished is deficient. A method of identifying and locating improperly abandoned wells is needed to eliminate this passage of containments.

## 5.0 WATER USAGE AND DEMAND

This section discusses the current uses of water from all ground and surface water sources in the District. The USGS and NRC has collected and processed water data from 1990 in an attempt to estimate water use in Nebraska. Estimates have been complied, on a county basis, for various water use categories. Results have not been published; therefore, provisional data is presented herein.

The 1990 study categorized water usage into four major uses: agricultural, municipal, domestic or industrial. Agricultural water use was segmented into cropland irrigation and livestock. The average daily and average yearly usage are presented in Table 19 from surface and groundwater sources. Table 20 presents the yearly average use for surface and groundwaters.

**Table 19. Water Usage in Burt, Dakota, Douglas, Thurston, Sarpy and Washington Counties[1] from All Sources, in 1990**

| Type of Use | Average Daily Usage (Ac-Ft) | Average Annual Usage (Ac-Ft) |
|---|---|---|
| Agricultural: | | |
| Cropland Irrigation | 147.2 | 53,710 |
| Livestock | 14.8 | 5,390 |
| Municipal | 377.8 | 137,900 |
| Domestic | 171.6 | 62,630 |
| Industrial | 93.8 | 34,250 |
| Total Estimated | 805.2 Ac-Ft/day | 293,880 Ac-Ft/year |

[1] This data represents the entire six county area. The NRD includes 61% of Thurston, 56% of Burt and all of Dakota, Douglas, Sarpy and Washington Counties.

Source: U.S. Geological Survey, Nebraska Natural Resources Commission, raw data, March 1993.

Municipal use accounts for 47% of the total average annual usage from surface and groundwater sources. Agricultural and domestic use are both approximately 20% of the total average annual usage. Groundwater provided 73% of the water source in 1992. The greatest user of surface water is municipal.

**Table 20. Water Usage in Burt, Dakota, Douglas, Thurston, Sarpy and Washington Counties[1] by Source, in 1990**

| Type of Use | Average Annual Use (Ac-Ft) Surface Water | Groundwater |
|---|---|---|
| Agricultural: | | |
| Cropland Irrigation | 5,780 | 47,930 |
| Livestock | 580 | 4,810 |
| Municipal | 72,830 | 65,070 |
| Domestic | -- | 62,630 |
| Industrial | -- | 34,250 |
| Totals (Ac-Ft/year) | 79,190 | 214,690 |

[1] This data represents the entire six county area. The NRD includes 61% of Thurston, 56% of Burt and all of Dakota, Douglas, Sarpy and Washington Counties.

Source: U.S. Geological Survey, Nebraska Natural Resources Commission, raw data, March 1993.

Tables 21 and 22 summarize the groundwater withdrawal for municipal, domestic, industrial and commercial water uses on a county and community basis, respectively. These numbers were estimated and discrepancies in the data were not resolved.

**Table 21. Municipal Groundwater Withdrawal and Delivery for All Uses, by County[1], 1990**

| County | Population (1990) | Municipal Withdrawal (mgd) | Domestic Delivery PWS (mgd) | Domestic Delivery RWS (mgd) | Industrial Delivery (mgd) | Commercial Delivery (mgd) | Total Domestic Industrial & Commercial (mgd) |
|---|---|---|---|---|---|---|---|
| Burt County | 7,868 | 1.04 | 0.51 | 0.00 | 0.07 | 0.21 | 0.79 |
| Dakota County | 16,742 | 2.97 | 1.29 | 0.12 | 0.16 | 0.31 | 1.88 |
| Douglas County | 416,444 | 0.60 | 34.88 | 0.03 | 9.20 | 23.56 | 67.67 |
| Thurston County | 2,936 | 0.60 | 0.29 | 0.05 | 0.06 | 0.10 | 0.50 |
| Sarpy County | 102,583 | 51.01 | 4.50 | 0.00 | 0.74 | 1.23 | 6.47 |
| Washington County | 16,607 | 1.88 | 0.92 | 0.03 | 0.10 | 0.32 | 1.37 |
| Totals | 563,180 | 58.10 | 42.39 | 0.23 | 10.33 | 25.73 | 78.68 |

[1] This data represents the entire six county area. The NRD includes 61% of Thurston, 56% of Burt and all of Dakota, Douglas, Sarpy and Washington Counties.

PWS = Public Water System RWS = Rural Water System

Source: U.S. Geological Survey, Nebraska Natural Resources Commission Raw Data, March, 1993.

**Table 22. Groundwater Withdrawal for All Uses, by Community, 1990**

| Community | Population (1990) | Municipal Withdrawal (mgd) | Domestic PWS Delivery (mgd) | Industrial Delivery (mgd) | Commercial Delivery (mgd) | Total Domestic Industrial & Comm. (mgd) |
|---|---|---|---|---|---|---|
| Arlington | 1,178 | 0.26 | 0.12 | 0.01 | 0.04 | 0.17 |
| Bellevue[1] | 30,982 | 0.00 | 3.10 | 0.66 | 0.69 | 4.45 |
| Bennington | 866 | 0.11 | 0.09 | 0.01 | 0.06 | 0.16 |
| Blair | 6,860 | 1.49 | 0.69 | 0.08 | 0.23 | 1.00 |
| Craig | 228 | 0.02 | 0.02 | 0.00 | 0.01 | 0.03 |
| Dakota City | 1,470 | 0.35 | 0.15 | 0.03 | 0.04 | 0.21 |
| Decatur | 641 | 0.18 | 0.06 | 0.00 | 0.03 | 0.09 |
| Elkhorn | 1,398 | 0.00 | 0.14 | 0.06 | 0.10 | 0.29 |
| Emerson | 791 | 0.17 | 0.08 | 0.01 | 0.02 | 0.10 |
| Ft. Calhoun | 648 | 0.00 | 0.06 | 0.00 | 0.02 | 0.09 |
| Gretna | 2,249 | 0.37 | 0.22 | 0.01 | 0.05 | 0.28 |
| Herman | 186 | 0.05 | 0.02 | 0.00 | 0.01 | 0.03 |
| Homer | 553 | 0.12 | 0.06 | 0.00 | 0.01 | 0.07 |
| Hubbard | 199 | 0.04 | 0.02 | 0.00 | 0.00 | 0.02 |
| Jackson | 230 | 0.03 | 0.02 | 0.00 | 0.01 | 0.03 |
| Kennard | 371 | 0.08 | 0.04 | 0.00 | 0.01 | 0.05 |
| LaVista[1] | 9,840 | 0.00 | 0.00 | 0.00 | 0.22 | 0.22 |
| Lyons | 1,144 | 0.21 | 0.11 | 0.06 | 0.05 | 0.22 |
| Oakland | 1,279 | 0.22 | 0.13 | 0.00 | 0.05 | 0.18 |
| Omaha MUD | 335,795 | 48.07 | 34.43 | 8.96 | 23.25 | 66.63 |
| Papillion | 10,378 | 2.25 | 1.04 | 0.06 | 0.23 | 1.33 |
| Pender | 1,208 | 0.26 | 0.12 | 0.05 | 0.04 | 0.21 |
| Ralston[1] | 6,236 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Rosalie | 178 | 0.00 | 0.01 | 0.00 | 0.01 | 0.02 |
| South Sioux City | 9,677 | 2.25 | 0.97 | 0.13 | 0.23 | 1.33 |
| Springfield | 1,426 | 0.31 | 0.14 | 0.01 | 0.00 | 0.15 |
| Tekamah | 1,852 | 0.40 | 0.19 | 0.00 | 0.07 | 0.26 |
| Thurston | 98 | 0.03 | 0.02 | 0.01 | 0.00 | 0.03 |
| Valley | 1,775 | 0.39 | 0.18 | 0.15 | 0.12 | 0.45 |
| Walthill | 747 | 0.15 | 0.07 | 0.00 | 0.02 | 0.10 |
| Waterloo | 479 | 0.10 | 0.05 | 0.03 | 0.00 | 0.08 |
| Winnebago | 705 | 0.15 | 0.07 | 0.00 | 0.02 | 0.09 |
| Totals | 425,425 | 58.09 | 42.41 | 10.33 | 25.65 | 78.39 |

[1] Groundwater supplied by MUD.

Source: U.S. Geological Survey, Nebraska Natural Resources Commission Raw Data, March, 1993.

Private wells provide water supply for irrigation, livestock, domestic, and industrial use; Table 23 summarizes the self-supplied ground and surface waters on a county basis. Over 50 % of the total self-supplied groundwater is used for irrigation.

**Table 23. Self-Supplied Water Usage for All Uses by County, in mgd**

| County | Rural or Unincorporated Population (1990) | Irrigation | | | Livestock | | | Mining | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | GW | SW | Total | GW | SW | Total | GW | SW | Total |
| Burt County | 2,650 | 17.36 | 1.98 | 19.34 | 0.92 | 0.11 | 1.03 | 0.00 | 0.00 | 0.00 |
| Dakota County | 2,340 | 5.09 | 0.10 | 5.19 | 0.31 | 0.05 | 0.36 | 0.00 | 0.00 | 0.00 |
| Douglas County | 68,990 | 6.88 | 0.09 | 6.97 | 0.40 | 0.07 | 0.47 | 0.00 | 5.55 | 5.55 |
| Thurston County | 47,810 | 3.95 | 0.24 | 4.19 | 1.11 | 0.10 | 1.21 | 0.00 | 4.02 | 4.02 |
| Sarpy County | 3,780 | 2.98 | 0.55 | 3.53 | 0.68 | 0.09 | 0.77 | 0.00 | 0.00 | 0.00 |
| Washington County | 6,980 | 6.53 | 2.20 | 8.73 | 0.87 | 0.10 | 0.97 | 0.00 | 0.13 | 0.13 |
| Total | 132,550 | 42.79 | 5.16 | 47.95 | 4.29 | 0.52 | 4.81 | 0.00 | 9.70 | 9.70 |

| County | Rural or Unincorporated Population (1990) | Domestic | | | Industrial | | | Total Self-Supplied | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | GW | SW | Total | GW | SW | Total | GW | SW | Total |
| Burt County | 2,650 | 0.26 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 18.54 | 2.09 | 20.63 |
| Dakota County | 2,340 | 0.23 | 0.00 | 0.23 | 2.51 | 0.00 | 2.51 | 8.14 | 0.15 | 8.29 |
| Douglas County | 68,990 | 6.90 | 0.00 | 6.90 | 1.28 | 0.00 | 1.28 | 15.46 | 5.71 | 21.17 |
| Thurston County | 47,810 | 4.78 | 0.00 | 4.78 | 16.44 | 0.00 | 16.44 | 26.28 | 4.36 | 30.64 |
| Sarpy County | 3,780 | 0.38 | 0.00 | 0.38 | 0.00 | 0.00 | 0.00 | 4.04 | 0.64 | 4.68 |
| Washington County | 6,980 | 0.73 | 0.00 | 0.73 | 0.01 | 0.00 | 0.01 | 8.14 | 2.43 | 10.57 |
| Total | 132,550 | 13.28 | 0.00 | 13.28 | 20.24 | 0.00 | 20.24 | 80.60 | 15.38 | 95.98 |

GW = Groundwater          SW = Surface Water

Source: U.S. Geological Survey, Nebraska Natural Resources Commission Raw Data, March, 1993.

Groundwater provides 75% of all municipal, domestic and industrial water requirements in the District. Registration is required for municipal, irrigation and industrial wells, which are inventoried in Table 24. Figures 19 and 20 show the location of registered municipal/industrial wells and irrigation wells, respectively. Since there are no registration requirements for domestic wells, it is difficult to determine the number of domestic wells within the District.

**Table 24. Active, Registered Wells in the P-MRNRD**

| County | Municipal | Irrigation | Industrial | Other | Total |
|---|---|---|---|---|---|
| Burt | 7 | 337 | 0 | 0 | 344 |
| Dakota | 17 | 105 | 6 | 1 | 129 |
| Dodge | - | 2 | - | - | 2 |
| Douglas | 39 | 254 | 9 | 39 | 341 |
| Sarpy | 63 | 102 | 26 | 11 | 202 |
| Thurston | 5 | 10 | 0 | 0 | 15 |
| Washington | 9 | 102 | 2 | 2 | 115 |
| Totals | 140 | 912 | 43 | 53 | 1,148 |

Source: Nebraska Natural Resources Commission Data Bank, March, 1993.

## 5.1 Domestic

Domestic uses of water include human consumption, sanitation and fire protection, as well as seasonal uses for landscaping irrigation and recreation areas. The P-MRNRD is the most highly populated NRD in Nebraska. Major groundwater concerns in the District focus on individual or community wells that provide potable water for human consumption, business and industry. These concerns are magnified near population centers that rely exclusively upon their relatively inexpensive, abundant groundwater resources for future growth and development.

Domestic water usage accounted for 21% of the total average annual usage in 1990. Public and rural water systems (RWS) deliver water to the District. RWS located in Washington, Thurston and Dakota Counties purchase treated water from nearby municipal systems for resale to the rural community. Of the total rural water delivered by the District, Dakota County RWS conveys 41%, Washington County RWS 41% and the Thurston County RWS 18%. Remaining rural households in the District have private wells to supply their water needs.

Two communities, Omaha and Blair, obtain water directly from the Missouri River. MUD services the communities of Omaha, Bellevue, LaVista and Ralston. The remainder of the communities have wells to supply their water needs. According to the Nebraska Department of Water Resources, there are 140 registered municipal wells (including SIDs) in use in the District (Figure 19).

There are also situations where water from sources within the P-MRNRD is used by communities outside the jurisdictional boundaries of the District, thus supporting adjacent NRDs. The City of Fremont situated in the Lower Platte North NRD, receives approximately 30% of its water from wells located in the P-MRNRD. These wells are located along the Platte River in northwestern Douglas County.

The City of Lincoln Water System (LWS) has purchased land in the P-MRNRD to develop a well field adjacent to the Platte River in southwestern Sarpy County. It is located immediately east of their present well field north and east of Ashland in Saunders County (Lower Platte North and Lower Platte South NRDs). Projected operation of this well field is during the 1990's.

Currently, the water used by MUD comes from three sources; 50% from the Missouri River, and 50% from combined wells within the Platte River well field (38 wells), and the Millard well field (6 wells). Areas of the Platte River well field encompass both Sarpy (19 wells) and Cass (19 wells) Counties. The MUD wells in Cass County are sited on the north side of the Platte River, making them technically and legally under the authority of the Lower Platte South NRD. Regardless of the location, this resource is considered a part of the P-MRNRD groundwater reservoir.

MUD has also purchased 1,000 acres of land in southwest Douglas County and 1,000 acres of land adjacent to the Platte River in the Yutan area of Saunders County (Lower Platte North NRD) in anticipation of developing a future well field. This well field (Platte West) is scheduled to be operational around the turn of the century.

The four major municipal well fields, either in or adjacent to the District, along the Platte River are MUD (Omaha), LWS, Fremont and Papillion. While most of the recharge is induced from surface flows in the Platte River, these operations potentially place a considerable demand on the Platte Valley Region groundwater reservoir.

## 5.2 Agricultural

The use of water in agriculture involves two main enterprises: crop production and livestock. The production of row crops accounts for the largest single use of land in the District.

**Cropland**

Irrigated cropland involves only 9% of all cropland acres in the District. In 1990, average annual groundwater use for irrigated cropland accounted for 22% of the yearly total (Table 20). According to DWR, there are 912 registered irrigation wells in the District (Figure 20).

The majority of cropland within the District are dryland farmed and a reliance upon irrigation is less cost effective. Several factors contribute to this trend away from irrigation: 1) the prohibitively large initial investment for new irrigation systems; 2) escalating energy costs to operate new or existing systems; 3) low commodity prices (potential yield increases under irrigation may allow less than "break even" for the system and its operation); 4) less attractive tax advantages for installing a new system; 5) increased acres planted utilizing minimum tillage techniques, thereby naturally conserving soil moisture; and 6) utilization of drought tolerant plant varieties.

The principal crops grown in this area consist of various rotations of corn, soybeans, alfalfa and small grains. However, even with the relatively high water requirements of some of these crops, natural precipitation--both preseason precipitation and during the growing phases--is generally quantitatively adequate (25-29 inches) and sufficiently timely to preclude the need for supplemental irrigation.

In addition to the ample rainfall, a majority of soils in the District are composed of silt loam or silty clay with virtually no sandy soils present. This type of soil structure tends to retain moisture more effectively than sandier soil types and lends support to good crop growth with less precipitation.

### Livestock

Water is also utilized in farming operations for livestock production, with supplies drawing from both surface and groundwater sources. The Department of Water Resources estimates that 5,390 Ac-Ft were consumed by livestock in 1990 and of this, approximately 4,810 Ac-Ft is supplied from groundwater sources.

### Subirrigation

Subirrigation, as defined for this Plan, is irrigation below the surface by a system of underground porous pipes. The P-MRNRD has virtually no areas that are considered to be subirrigated within its boundaries. Thus, no information is presented on subirrigation uses.

## 5.3 Industrial

Water used for industrial purposes include, but is not limited to, fertilizer processors, meat processors, cement processors and petroleum refineries. There are 43 registered industrial wells in the District. In 1990, the NRC estimated that the total amount of water used for industrial uses was 34,250 Ac-Ft from all sources.

## 5.4 Other Plant and Animal Species

Surface water is the predominant source of water used by fish and wildlife, however, no estimate of usage can be made.

Other plants, including some threatened and endangered species, may be affected by groundwater levels. In particular, the Nebraska Games and Parks Commission has determined that the habitat for the western prairie fringed orchid may occur in the District. As a rule, this threatened plant is only found in wet areas of native, tall grass prairies. There has not been a comprehensive study to identify native prairie areas, or populations and habitats of the orchid, however, one sighting of this plant has been made in the Krebs Prairie locateed in south central Sarpy County.

In general, protection of groundwater quantity and quality has many benefits, including protecting the habitats of the threatened species listed above. The groundwater activities listed in Section 7.0 of this plan may have both positive and negative impacts on threatened species.

Should specific adverse effects on the orchid, or other threatened species, from changing groundwater levels be identified, the District will evaluate the need to modify the plan in the future. Such modifications should include actions within management or control areas consistent with the Nebraska Groundwater Management and Protection Act, that could be taken by the District to reduce adverse effects on threatened species by maintaining a goundwater level that will help sustain the species.

## 5.5 Recreation

No information was obtained on water usage and demand for recreation.

## 5.6 Value of Groundwater

There is insufficient data available to estimate the value of groundwater use. However, an indication that a value does exist can be shown.

In agriculture, irrigation of crops will increase yields. For example, in 1983, the Nebraska Crop and Livestock Reporting Service data show that non-irrigated corn produced 90 bushels of corn per acre while irrigated corn produced 120 bushels per acre on the average. For soybeans, the yields were 34 bushels per acre and 40 bushels per acre, respectively. The value of these additional bushels and subsequent income can be attributed to irrigation.

However, a decrease in irrigation practices would not cause a major shift from production to less intensive land uses. The precipitation patterns within the region provide sufficient moisture available during the growing season to offset any reduction of irrigation. For example, the Cooperative Extension Service estimates that to produce the average crop of corn (90 bushels/ac.), 24-25 inches of water is required. This water could come from precipitation, stored subsoil moisture and/or irrigation. Since the District receives, on the average, 22 inches of precipitation during the spring and summer months, extensive irrigation development may be only marginally feasible from an economic standpoint.

Placing a dollar value on groundwater supplies for domestic or municipal usage is extremely difficult. If, however, a public or private water system is threatened either by quality or quantity problems, resolutions may be very costly. Extenuating circumstances pertinent to individual situations exist that may allow a multitude of solutions, e.g.--individuals or communities with either poor quality or unreliable quantity might obtain a better water supply from an adjoining community or rural water supply project at minimal cost to the individual user. A relatively expensive well drilling, water treatment plant, water hauling, etc. solution could be the scenario in a different situation.

It may be less expensive to develop and operate a regional system with one source serving several communities rather than each community maintaining its own system. Regional systems are preferred in the District and should be promoted whenever possible.

These two extremes suggest the futility of attempting to place a value on dependable supply of good quality water for individuals, business and industry. The task to define such an intangible figure or value, with any degree of validity, must be handled on a case by case basis. Even so, varying results are virtually endless--affected by degrees of quality and/or water loss and a multitude of differing circumstances--as to render conclusions at best inaccurate.

In the municipal-domestic and industrial categories, the majority of the water used comes from surface water, i.e., the Missouri River. Those municipalities which utilize groundwater as the source could convert to another source if the existing source becomes unusable. The cost of conversion from one source to another could be used to estimate the value. It is beyond the scope of this plan to estimate the conversion cost from one source of water to another, mainly because each municipality or industry would present a different set of circumstances requiring differing solutions.

## 5.7 Needs and Data Deficiencies

The USGS has estimated the amount of water use from ground and surface water sources in the United States every 5 years since 1950. In 1990 the NRC and USGS estimated water uses categories. All the data requirements were not available and estimates were made on information from other sources. Preliminary data was used for this section of the plan. The USGS was responsible for the preparations of the final report which is to be published at a later date. Tabular revisions may be necessary to reflect changes between final and preliminary data.

## 6.0 IDENTIFICATION OF CRITICAL AREAS FOR PROTECTION

The P-MRNRD has not identified any critical areas for protection.

## 7.0 GROUNDWATER QUALITY GOALS AND OBJECTIVES

### 7.1 Policy

**Groundwater Reservoir Life Goal and Management**

The District's goal is to maintain the existing conditions of its groundwater reservoir quantity and quality--forever. This "in-perpetuity" quality and quantity life goal applies to the entire P-MRNRD.

**Controls and Other Programs**

The P-MRNRD believes that its policy goals and objectives can be achieved without designating either a management or control area at this time. Relevant quantity issues, as demonstrated in Sections 1 through 6, are generally not applicable to this area. Similarly, it would be premature to suggest considering a management, control, or special protection areas based upon quality issues prior to determining if a quality problem exists or is likely to exist.

It should be noted that if rules and regulations were adopted for a management, control or special protection areas, they could be difficult, if not impossible to enforce for the Federally controlled (Bureau of Indian Affairs) Trust Land. Trust Land in the District currently totals over 50,000 acres and essentially all of it is within Thurston County.

**Water Conservation**

Quantity is not now, nor is it anticipated to be a major concern of the District in the foreseeable future. Conservation techniques currently utilized in the District are more in the form of emergency measures during periods of dry weather. For example, a municipal supplier may request that citizens refrain from watering their lawns for a short period of time to help meet peak demands for other uses.

Water used in the District comes from either surface or groundwater sources, with groundwater supplying the greatest amount. The predominant use of water is for municipal/domestic purposes. This situation is expected to continue into the future as more land is converted to urban uses and as population increases.

According to available data, the groundwater reservoir has sufficient quantity to meet the demands placed on it. Previous discussion in Section 5.0 indicated that there probably won't be a dramatic increase in irrigation development in the District. Municipal/domestic uses are expected to increase in the future, however, large quantities of water could be obtained from wells in the Platte Valley Area, or from surface water in the Missouri River.

Surface water from the Missouri River supplies approximately 36% of the water used for municipal/domestic purposes in the District. The 1990 annual withdrawal of 72,830 Ac-Ft. (Table 20) from the Missouri River is approximately equal to only 0.3% of annual average flow in the river at Omaha (Table 4: 23,180,000 Ac-Ft/year). This represents a vast source of surface water available to the District which could be used to supplement and/or replace existing systems should they no longer have sufficient supplies.

Therefore, it appears that the available supply of water, both surface and groundwater, is sufficient to meet the usage demands for the future. It is understood that the District's current static water level monitoring program displays seasonal fluctuations in wells that are directly related to relatively short term, localized precipitation events, or droughts, rather than irrigation usage. These fluctuations are not considered to be symptoms of long term aquifer degradation. Efforts to monitor groundwater quantities should be continued.

The District is actively engaged in promoting water and other conservation practices through ongoing educational programs and projects. The P-MRNRD will also continue to support pertinent research proposals from individuals or agencies.

**Conjunctive Use and Supply Augmentation**

Policy governing the conjunctive use of surface water and groundwater has not been developed by the P-MRNRD. Irrigation, as previously emphasized, utilizing either surface or groundwater resources, is not considered a major factor in the future development of a management plan for this District's water resources.

The District will continue to lend its full support to all feasible rural water supply projects within our boundaries. Excepting rural water systems(s), the P-MRNRD feels that its policy goals and objectives can be achieved without developing conjunctive management, water conservation measures, or other supply augmentation programs at this time.

**Groundwater Quality**

Groundwater quality issues will continue to be the focus of this groundwater management plan, not because of known quality problems, but of potential, unknown ones.

The District recognizes that a groundwater quality problem exists in domestic wells in isolated areas in the NRD. Although the data indicate poor well construction and/or location to be the major contributing factors, these point-source problems may be indicators of potentially more widespread quality problems.

As presented earlier, the potential for contamination of the groundwater is high, due to the concentration of industries, including agriculture, utilizing or producing potentially hazardous materials. Since neither DEQ or the health departments systematically monitor groundwater in the District, there appears to be a need for such monitoring activities.

The District has established its policy goal of maintaining its present groundwater quality in perpetuity. However, this rather ambitious groundwater life goal is based upon limited groundwater data for eastern Nebraska. To state that the District will maintain its groundwater reservoir quality forever, without knowing its current status may be considered unwise. However, if quality problems are evidenced, the District will work towards achieving quality levels that are acceptable and maintain these levels indefinitely.

## 7.2 Groundwater Management Objectives

The following groundwater management objectives are intended to achieve the reservoir life goal.

Objective 1: Maintain the District's static water level monitoring program.

In order to detect evidence of "mining" of groundwater, wells will need to be measured over a long period of time. This District program has been in effect for fourteen years, however, only thirty-one (31) wells have been monitored. In 1994, some of the wells mentioned in Objective 2 will be included in this program to widen the database. Currently, measurements are taken in the spring and fall by District personnel and will continue.

Objective 2: Establish a District-wide groundwater quality monitoring program.

As described in Section 3.0 of this Plan, a groundwater quality monitoring program is being established for the entire District. The initial sampling effort in 1992 was accomplished under contract with the U.S. Geological Survey. During 1992, samples from 61 wells were collected and analyzed (results are shown in Appendix F). In 1994, this monitoring effort will be expanded to 92 wells as identified by USGS in 1992. The District intends to contract with USGS for sampling and analysis of these thirty-one (31) additional wells. In subsequent years, samples will be collected and analyzed for all 92 wells on a four year cycle, or approximately 23 wells per year.

Groundwater quality is also monitored by the NDEQ in areas of potential point sources and in areas of known contamination. The County Health Department's and NDOH currently monitor water for human consumption. In many cases, routine testing of municipal systems detects contamination which warrants further investigation. These efforts of NDEQ and NDOH are expected to continue.

A relatively high percentage of well water samples tested through the County Cooperative Extension's voluntary program showed contaminant levels exceeding present water quality standards. However, the exact location of these wells are not provided and the sampling methods may be in question. An effort will be made to obtain this data in a usable format and incorporated into the water quality data inventory.

Objective 3: Administer the Nebraska Chemigation Act in the District.

This program was established in 1986. Irrigators who apply fertilizers or pesticides through center pivot irrigation systems must have measures in place to prevent those chemicals from contaminating the groundwater supply. District personnel inspect these systems and issue permits certifying that these backflow prevention devices are in place and functional.

Objective 4: Encourage, through information and education activities, conservation of water quantity and quality.

Although the data does not document a water quantity or quality problem, the wise use of water should be promoted in all activities. Urban users and agricultural irrigators need to be encouraged to employ best management in their use of water. Industries, agencies and residents of the District would also be educated about methods to prevent groundwater contamination.

Existing information and education programs will continue to be targeted towards this objective. This includes the District's newsletter, public service announcements, and brochures.

Objective 5: Establish management, control, or special protection areas in the District to address specific problems of groundwater quality, should the data collected indicate that the groundwater reservoir life goal cannot be met.

In addition to management and control areas, the District may also utilize special protection areas to address water quality problems. Establishment procedures are specific in the statutes and the need must be justified by reliable data. The foregoing objectives will help supply the necessary documentation. The NRD Board of Directors will decide whether or not to establish these areas on an individual basis.

The stated policy of maintaining existing conditions demands a high degree of accuracy when monitoring change in the groundwater quality as well as the establishment of flexible action plans to address problems should they occur. The key to sustaining the current groundwater conditions is to develop a plan which is focused on the early detection of any deterioration of this resource.

The District intends to manage this resource utilizing a three phase approach: 1) Routine periodic sampling of the entire District; 2) Special monitoring and evaluation of identified problem areas; and, 3) Remediation of problem areas through education and implementation of best management practices. The purpose of these phases is to establish a database from which to detect change, develop procedures for the identification and subsequent evaluation of threatening conditions, and to establish a preliminary series of action steps to mitigate these problems.

A flow chart depicting these phases is shown in Figure 21, and is described in the following steps. The numbers referred to in the various boxes in the figure correspond to the steps below.

1. The periodic sampling program will collect data from 92 wells randomly distributed throughout the District. Samples from each well will be collected every four years and analyzed for the parameters listed in Appendix F.

2. The results of the periodic sampling program will be used to establish the baseline defining existing conditions. It will also form a basis for comparison to detect changes in water quality requiring future actions.

3. When a change from the baseline condition is identified by Step 2, additional testing is indicated. This testing may be of increased density (more wells), increased detail (more parameters), increased frequency of tests, or a combination of all of the above.

4. Preliminary investigations will be conducted based on data collected in Steps 1 and 3 which is responsive to the character of the problem. The scope of this investigation must be varied so that the areal extent, or severity of the deviation from the baseline can be taken into consideration. These investigations will be responsive to the problem and not necessarily limited to Title 118 criteria.

5. If the results of Step 4 indicate the problem is localized (one or two landowners), specific action items will be initiated.

6. These site specific action steps begin with an information/education program to provide the landowner with the results of the preliminary investigation and to supply alternatives to mitigate the problem.

7. The preliminary investigation will also identify specific best management practices (BMP) to be implemented.

8. A special testing cycle will be implemented to evaluate the effectiveness of the BMPs implemented.

9. If Step 5 indicates the problem is more areally extensive, a detailed investigation will be conducted.

10. If the level of the parameters sampled exceeds 0.5 of the maximum contaminant level (MCL) listed in Title 118, a management, control, or special protection area will be strongly pursued by the District.

11. An areawide information/education program will be implemented in the affected area identifying the nature of the problem and any precautions which need to be followed.

12. A specific action plan will be developed which is based on the detailed investigation and will be designed to address the problem.

13. BMPs will be implemented as identified in Step 12.

14. The number, frequency, and detail of testing in the vicinity of the problem area will be increased to monitor the effectiveness of the BMPs implemented.

In all cases, the identification of a change in groundwater conditions will result in more intensive monitoring, evaluation, and education.

<u>Objective 6: Establish management or control areas in the District to address problems of groundwater quantity, should the data collected indicate that the groundwater reservoir life goal cannot be met</u>.

The available data does not indicate a groundwater quantity problem in the P-MRNRD. The current monitoring program described in Objective 1 shows that groundwater levels have not significantly changed, either increase or decrease, in the past 10-15 years. The groundwater reservoir appears to be fully recharged each year and is able to meet the demands for water for all beneficial purposes.

The District does not propose the establishment of a management or control area for quantity at this time. However, future conditions may warrant such establishment. Should the groundwater level monitoring effort (Objective 1) reveal a decline in the water level of twenty-five (25) feet below the baseline for two consecutive years, the District proposes the following action plan. The baseline for comparison is hereby set as the average of static water levels from the last three years (1991, 1992, and 1993).

The District intends to manage this resource utilizing a three phase approach: 1) Routine periodic inventory of selected wells within the District; 2) Monitoring and evaluation of identified problem areas; and, 3) Remediation of problem areas through education and implementation of best management practices (BMPs). The purpose of these phases is to establish a database from which to detect change, develop procedures for the identification and subsequent evaluation of threatening conditions, and to establish a preliminary series of action steps to mitigate these problems.

A flow chart depicting these phases is shown in Figure 22, and is described in the following steps. The numbers referred to in the various boxes in the figure correspond to the steps below.

1. A periodic inventory program will collect static well level data from wells uniformly distributed throughout the District. Samples from each well will be collected annually and evaluated for one year and two year declines in water elevation.

2. The results of the inventory program will be used to establish a baseline which defines existing conditions. It will also form a basis for comparison to detect changes in the groundwater levels, thus requiring future action.

3. When a change from the baseline condition, in excess of a 25' decline in a single year, is identified by Step 2, additional inventory is indicated. This will result in an increased density of well inventory.

4. A preliminary investigation will be conducted based on data collected in Steps 1 and 3. The scope of this investigation will be varied so the areal extent, or severity of the deviation from the baseline can be taken into consideration.

5. If the results of Step 4 indicate the problem is localized (one or two landowners), site specific action items will be initiated.

6. These site specific action steps begin with an information/education program to provide the landowner or owners with the results of the

preliminary investigation and to identify alternatives to mitigate the problem.

7. The preliminary investigation will also identify specific best management practices (BMP) to be implemented. These BMPs will reflect the most current technology available.

8. A special testing cycle using an increased monitoring density will be implemented to evaluate the effectiveness of the BMPs implemented.

9. If Step 5 indicates the problem is more areally extensive, a detailed investigation will be conducted.

10. If the groundwater decline exceeds 25' from the baseline for two consecutive years, a management or control area will be strongly pursued by the District.

11. An areawide information/education program will be implemented in the affected area identifying the nature of the problem and management options which need to be followed.

12. A specific action plan will be developed which is based on the detailed investigation and will be designed to address the problem.

13. BMPs will be implemented as identified in Step 12.

14. The density of testing in the vicinity of the problem area will be increased to monitor the effectiveness of the BMPs implemented.

In all cases, the identification of a change in groundwater conditions will result in more intensive monitoring, evaluation, and education.

Objective 7: Continue to evaluate requests (petitions) from rural landowners for a more adequate and dependable water supply.

The District's Improvement Project Area authorities can be utilized to install and operate rural water systems in Nebraska. The Papio-Missouri River NRD Board of Directors will continue to respond to petitions from rural groups needing a dependable, high quality water supply.

Objective 8: Cooperate with other NRDs in the management of contiguous portions of the groundwater reservoir.

The District borders on the Lewis & Clark, Lower Elkhorn, Lower Platte North and Lower Platte South NRD's. Portions of the groundwater reservoir are continguous with these NRDs. Management activities will be coordinated as needed.

Objective 9: Establish a well abandonment cost sharing program in the District

Abandoned wells that are not properly sealed provide a direct conduit to the groundwater reservoir for a wide variety of potential contaminants. This program will encourage landowners to follow accepted procedures to abandon a well.

Objective 10: Encourage development of regional water supplies in the District

Federal drinking water standards have been adopted that have become more strict in recent years and probably will become more so in the future. Smaller communities in the District may be forced to replace their treatments facilities to meet these new standards. It may be less expensive to develop a regional system with one treatment plant serving several communities rather than each community maintaining its own system. The District, under its rural water authorities, could operate the combined systems. The Nebraska state agencies providing oversight of public water systems should also promote regional systems whenever possible.