GROUNDWATER MANAGEMENT PLAN

NORTH PLATTE

NATURAL RESOURCES DISTRICT

NOVEMBER 1993

OLSSON ASSOCIATES
LINCOLN, NEBRASKA

REVISED GROUNDWATER MANAGEMENT PLAN
NORTH PLATTE NATURAL RESOURCES DISTRICT
NOVEMBER 1993

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ADDENDUM

LIST OF ACRONYMS

ASCS	Agricultural Stabilization and Conservation Service
BMP	Best Management Practices
CA	Control Area
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CDC	Nebraska Department of Health Center for Disease Control
CSD	Conservation and Survey Division
CWA	Clean Water Act
DEC	Nebraska Department of Environmental Control (now DEQ)
DEQ	Nebraska Department of Environmental Quality (formerly DEC)
DOH	Nebraska Department of Health
DWR	Nebraska Department of Water Resources
EPA	U.S. Environmental Protection Agency
ET	Evapotranspiration
FmHA	Farmers Home Administration
G & P	Nebraska Game and Parks Commission
GWMA	Groundwater Management Area
GWMP	Groundwater Management Plan
GWMPA	Groundwater Management and Protection Act
LUST	Leaking Underground Storage Tanks
MCL	Maximum Contaminant Level
msl	mean sea level (Datum for USGS elevations)
NAWQUA	USGS National Water Quality Assessment Program
NPDES	National Pollutant Discharge Elimination System
NPNRD	North Platte Natural Resources District
NPS	Nonpoint Source (of contamination)
NRC	Nebraska Natural Resources Commission
NRD	Natural Resources District
NWQL	U.S. Geological Survey National Water Quality Laboratory
PMCL	Primary Maximum Contaminant Level
PS	Point Source (of contamination)
RCRA	Resource Conservation and Recovery Act

SCS	U.S. Department of Agriculture Soil Conservation Service
SMCL	Secondary Maximum Contaminant Level
SPA	Special Protection Area
T	Transmissivity
TDS	Total Dissolved Solids
UNL	University of Nebraska-Lincoln
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WHPA	Wellhead Protection Area

ABBREVIATIONS AND CONVERSION FACTORS

cfs or ft^3/sec = cubic feet per second

AF or af = acre-foot or acre-feet

gpm = gallons per minute

Conversion Factors

cfs x 1.9835 = acre-feet per day (AF/d)

Example: 10 cfs = approximately 20 AF/d

cfs x 59.51 = acre-feet per 30-day month

Example: 100 cfs - 5,951 AF/mo

cfs x 724 = acre-feet per 365-day year

Example: 1000 cfs = 724,000 AF/year

1 cfs = 7.48 gallons per second (gps)

1 cfs = 448.8 gpm

2 cfs = approximately 900 gpm

1 acre-foot = 325,851 gallons

1 day = 1440 minutes

Examples: 1 gpm = 1440 gpd

100 gpm = 144,000 gpd or 0.44 AF/d

1000 gpm = 1,440,000 gpd or 4.4 AF/d

750 gpm = approximately 1,000,000 gpd or 3.3 AF/d

Chemical Concentrations, Abbreviations and Equivalencies

parts per million (ppm) = milligrams per liter (mg/l)

1 microgram per liter (µg/l) = 1 part per billion (ppb) or 0.001 mg/l

Example: manganese, 50 µg/l = 0.050 mg/l

picocuries per liter = pCi/L (radioactive term)

Example: uranium, 10 pCi/L = 30 ppb or 0.030 mg/l uranium - 238

1.0 Introduction

In 1984, the Nebraska Legislature passed LB 1106, a statute which required Natural Resources Districts (NRD's) to prepare groundwater management plans based on available information and to submit them to the Department of Water Resources (DWR) for review by January 1, 1986. This legislation was the result of growing concerns about groundwater supplies, historical groundwater declines and projected declines in this valuable resource. The North Platte Natural Resources District (NPNRD), with the assistance of Olsson Associates, Consulting Engineers, prepared and adopted a Groundwater Management Plan (GWMP) in September 1986, after the plan had been approved by the DWR.

Then, in 1991, due to growing concerns about groundwater contamination, the Nebraska Legislature passed LB 51. This statute required the NRD's to amend their existing GWMP's to address water quality. The NPNRD, again enlisting the services of Olsson Associates, decided to not only amend the existing GWMP but to completely revise and update the seven year old plan to reflect current thoughts on groundwater management.

This 1993 plan is a stand-alone document replacing the 1986 GWMP. The original intent of the NPNRD's 1986 plan, including the Groundwater Reservoir Life goal and all other goals and objectives, has been carried over into this plan, while programs and future plans have been revised to reflect current concerns with added emphasis on groundwater quality issues.

This plan is organized in the format recommended by the Nebraska Department of Environmental Quality (DEQ) and the Nebraska Department of Water Resources in their joint publication "Reference Outline - Groundwater Management Plan Amendments" dated July 1992. Information carried over or updated from the 1986 GWMP has been re-organized to fit into this format.

1.1. Previous NRD Groundwater Planning Efforts

1.1.1. 1986 Groundwater Management Plan

The 1986 GWMP (Reference 179) was created to fulfill a requirement of LB 1106, passed by the 1984 Nebraska Legislature, to address concerns about threatened groundwater supplies. Addressing mainly groundwater quantity, this plan established the Groundwater Reservoir Life Goal and presented the NPNRD's management objectives and the programs planned to achieve that goal. The NRD's groundwater management policies and implementation practices were also discussed. The 1986 plan did include considerable discussion of groundwater quality issues and included some program plans to maintain or improve groundwater quality.

The 1986 GWMP has been successfully implemented by the NPNRD over the past seven years.

1.1.2. An Investigation to Determine the Source of Elevated Nitrate Concentrations in the Groundwater of the North Platte River Valley West of Oshkosh.

This report (Reference 118) was authored by Mary Exner Spalding, a hydrochemist with the Conservation and Survey Division (CSD), Institute of Agriculture and Natural Resources, University of Nebraska, in February 1990. This study was completed under contract with the NPNRD in response to increased nitrate-nitrogen concentrations in sampled domestic wells in the area west of Oshkosh. The investigation was undertaken to determine the source of the nitrate contamination. The conclusion reached was that "The presence of all the factors that cause the groundwater to be highly vulnerable to nonpoint nitrate contamination, namely, the continuous production of irrigated corn on well-drained soils with a very shallow water table, indicates that the contaminant is from a nonpoint or dispersed source," that is, heavy application of both nitrogen fertilizer and irrigation water.

1.1.3. North Platte Valley Water Quality Project Proposal.

This document (Reference 116) was written in support of a NPNRD application for Section 319 funds. In this project, the NPNRD proposes to use an information campaign targeted at the public and the agricultural community. Targeted audiences in the agricultural community are landowners and operators. Additional targeted programs are aimed at garden clubs, civic groups, county and city officials, schools, and the business community. The increased awareness requires specific one-on-one technical assistance. Technical assistance centers around the use of the Resource Management System approach as outlined in the USDA-SCS Field Office Technical Guide. Best management practices will be carried out to minimize nitrate impact to the groundwater and vadose zone. This type of system approach will also reduce the surface water contamination potential. To improve nitrogen use efficiency by reducing the amount of leached nitrate, improvements to irrigation water management will be pursued.

Federal and state agencies involved with the project are as follows: University of Nebraska Cooperative Extension Service, Conservation and Survey Division UNL, Agricultural Stabilization and Conservation Services, USDA Soil Conservation Service, Panhandle Resource Conservation and Development, and the North Platte Natural Resources District. The proposal was accepted and approved for 319 funding. The project is now being implemented by the NPNRD.

1.1.4. USGS - NPNRD Cooperative Study.

This water resources investigation by the U.S. Geological Survey (Reference 152) is now in the pre-publication review phase. The study was done in cooperation with the NPNRD, the Nebraska Natural Resources Commission (NRC), and CSD. The study involved a comprehensive reconnaissance survey of groundwater quality in the NPNRD during June and July of 1991. The report on this investigation is expected to be released within the next year.

1.2. Progress to Date Towards Achieving the Groundwater Reservoir Life Goal.

This section reviews progress made towards implementing the objectives of the 1986 Groundwater Management Plan. In each case, the 1986 objective is stated followed by a listing of programs planned in support of that objective and a description of the progress made and progress still expected in that program.

1.2.1. Establishment of Groundwater Baseline Data.

1.2.1.1. *Water level data collection, compilation, and monitoring system review.*

The number of water level monitoring wells has been increased from 40 to 143 and the number of continuous recorder wells has increased from one to four. There are 86 additional wells being measured biannually in the alluvium of the North Platte River and its tributaries in Garden County as part of a local study. In a cooperative study between the Conservation and Survey Division and the NPNRD, water levels at 22 sites are being measured for the University Lake project. There are three multilevel continuous recorder wells operating on this project. Groundwater levels are also being gathered at the Crescent Lakes Wildlife Refuge by the Fish and Wildlife Service.

1.2.1.2. *Collection and compilation of geologic data from logs of wells which have been drilled.*

This information has been gathered from registered irrigation wells, oil and gas wells, and from NRD and CSD special project test drilling. A new state law will make registration of all wells mandatory and this information will also be available starting in 1993. This is an ongoing program to gather information on lithology, well construction, well yield, drawdown and other data from wells drilled in the NRD.

1.2.1.3. *Water quality data collection, compilation, and monitoring system review*.

Three dedicated multi-level monitoring wells and 16 additional observation wells have been installed in the alluvium of the North Platte River Valley as part of the studies conducted by NPNRD, CSD and USGS for determining the cause and extent of agricultural chemical contamination in Garden County.

Water samples from 75 domestic wells have been taken for nitrate and bacteria. Forty of these wells are sampled on a biannual basis to determine changes in nitrate concentrations.

There has been some preliminary sampling to investigate water quality problems in the Mitchell area and in the Haig area. Sampling has been done for nitrate and bacteria in these areas. It is anticipated that further effort in these areas will begin in 1993.

1.2.1.4. *Computerized groundwater data, filing, retrieval, and analysis capability.*

The NRD has all records for water levels measured by the district in a database which is updated each time new levels are measured. Information from the database is used to analyze water level changes. Development of a similar database for water quality is under development. The NRD hopes to integrate this information into a G.I.S. system for the district in the future.

1.2.1.5. *Development and calibration of an integrated model of groundwater and surface water quality.*

There are plans only for small scale local models at this time. Likely candidate areas are the North Platte River Valley in Garden County and the University Lake study area. Detailed information on the hydrogeology of these areas is being gathered at this time. It is hoped that enough information from ongoing projects in these areas will be sufficient to model these areas.

1.2.1.6. *Coordination of groundwater data collection and analysis with other agencies.*

All data collected is shared with Conservation and Survey Division (CSD), the U.S. Geological Survey (USGS), the Department of Environmental Quality (DEQ), and the Nebraska Natural Resources Commission (NRC).

1.2.2. Emphasis of Groundwater Conservation.

1.2.2.1. *Education and research targeted to improve management and operation of groundwater use systems.*

An Information and Education Specialist has been hired by the NRD to implement a public information program. The specialist will produce and distribute newsletters and brochures, coordinate public meetings, work with local schools and students and work to raise public awareness of these issues.

1.2.2.2. *Development of a drought management and education program in cooperation with State and Federal Agencies.*

There has been no progress here by the NRD. Some studies and contingency plans have been done by the Drought Assessment and Response Team (DART), an organization which includes representatives from a number of State and Federal agencies, and the University of Nebraska. These plans are available in brochure form.

1.2.3. Maintenance and Improvement of Groundwater Quality.

1.2.3.1. *Encouragement of best management practices (BMP) use in agricultural and urban areas.*

The NRD is cooperating with the SCS and ASCS to provide cost share incentives to improve water use efficiency and tillage practices to protect water quality in the district. The NRD is also cooperating in the Garden County Water Quality Incentive Program by supporting SCS and ASCS efforts to improve water quality in this area. Monies for this program go to water and fertilizer management planning for farms located in the North Platte River Valley.

1.2.3.2. *Monitoring of agricultural/industrial chemical pollution.*

The NRD monitors agricultural (nonpoint source) chemical pollution. Industrial point source pollution of the groundwater needs to be addressed.

The NRD monitors groundwater quality on a district wide and a local area basis. An earlier program consisted of taking annual samples from a network of wells located across the district. Forty-two of these wells were sampled every year with an additional 25 to 30 wells sampled from each county on a four year rotational plan. This program will be modified in the future as circumstances deem appropriate.

A cooperative effort between the NRD, USGS and CSD to do a reconnaissance of groundwater quality in the district was completed in 1991. A total of 120 wells were sampled and a report on the findings of this study is expected to be published in 1993 (Reference 152).

Information from previous NRD studies and data gathered during the summer of 1991 for the cooperative USGS, NRD, CSD groundwater quality study will be used in development of the future district wide monitoring program. Information from the DRASTIC map for the State of Nebraska and other sources will also be used in developing future studies.

Local studies are done by the district in response to discovery of nonpoint source contamination of groundwater. Presently there are three ongoing studies in the district, which include: the North Platte River Valley in Garden County, the Mitchell area, and the Haig area. Potential study areas include Pumpkin Creek Valley, southern Banner County and the Minatare area.

These studies are being done to determine the cause and extent of detected agricultural chemical pollution. They are carried out by the NRD and, when appropriate, other agencies in cooperative efforts. Currently the NRD is cooperating with USGS on the Platte River Valley in Garden County study.

The NRD started a cooperative study on surface water quality with the USGS in April 1993. Information from this study will be incorporated into future water quality monitoring efforts.

There is no current program for monitoring industrial pollution in the NRD.

1.2.3.3. *Research and analysis to determine what relationship exists between surface irrigation water and groundwater quality.*

The NRD has cooperated with the USGS and CSD in the preparation of their draft Water Resources Investigation Report titled "Reconnaissance of the Groundwater Quality in the North Platte Natural Resources District, Western Nebraska, 1991" (Reference 152). A cooperative study for the reconnaissance of surface water in the NRD was started in April 1993. Information from these two studies will be used to develop a plan of study to determine the relationship between groundwater and surface water quality.

1.2.3.4. *Encouragement of Comprehensive Enforcement of Oil and Gas Commission rules and regulations regarding exploration and well abandonment.*

No efforts have yet been made in this area.

1.2.3.5. *Monitoring and coordination of other agencies efforts to promote proper management and construction of water supply, drainage, and disposal systems.*

The NRD has worked with the U.S. Soil Conservation Service (SCS) on drainage and flood control programs in the district. Two of the more important programs are the Gering Valley Drain Flood Control Project, and the Harrisburg Rural Water District Water Supply Program.

1.2.3.6. *Encouragement of DEQ to coordinate with NRD programs for groundwater protection strategies.*

The NRD has worked with DEQ to produce a Section 319 grant from the Clean Water Act for working with groundwater contamination in Garden County. The program started in October of 1992 and will continue through 1995.

1.2.3.7. *Cooperation with State agencies towards development and enforcement of adequate regulations for uranium mining and other mineral mining explorations and operation.*

No efforts have been made in this area. No interest in this type of mining has been shown in this region. No active exploration is going on at this time.

1.2.3.8. *Identification of radioactive contamination potential.*

The topic of radioactive contamination was covered in great detail in the USGS Groundwater Quality Cooperative Study (Reference 152).

1.2.3.9. *Encouragement of regulatory agencies to research the impact of injection wells on water quality.*

There have been no efforts in this area to date.

1.2.3.10. *Maintenance of awareness and knowledge of current technology for treatment methods to improve water quality.*

No progress has been made.

1.2.4. Promote Research to Gain Understanding of Current Areas of Concern to Develop Groundwater Management Policies.

The NRD has actively promoted research in this area by participating in the USGS Water Quality Cooperative Study. This area is also addressed in the Water Quality Program Proposal for Section 319 funding.

1.2.4.1. *Encourage research in the Pumpkin Creek Valley to better understand the Brule Formation.*

There has been no recent work in this area. Research by Jeff Gottula of CSD resulted in a report titled "Groundwater Levels in Pumpkin Creek Valley, Western Nebraska, 1980" (Reference 100). CSD is currently studying an area in Cheyenne County that may also be applicable to the Pumpkin Creek area. Steve Sibray of CSD should finish this report sometime in 1993. Installation of two additional recorder wells are being planned by the NRD.

1.2.4.2. *Encourage research to better understand the Chadron Sand aquifer, particularly in the Horseshoe Bend area.*

The NRD has installed a continuous recorder well and has plans to cooperate with CSD and USGS in monitoring an additional two or three existing irrigation wells. Data will be kept in a data base. No reports are planned at this time.

1.2.5. Understand the Surfacewater/Groundwater Interaction in the North Platte Valley.

1.2.5.1. *Encourage research to improve understanding.*

The NRD is assisting CSD in a study on the effects of groundwater recharge from unlined canals at University Lake. There has been one year of monitoring water levels from 54 sites in the project area. This information is currently being analyzed by Anne Matherne of CSD and work is expected to continue for the next few years.

1.2.6. Explore Integrated Management and Supply Augmentation Measures.

1.2.6.1. *Re-evaluate existing reports and initiate feasibility studies for providing supplemental groundwater supplies.*

The NRD is investigating plans to develop a water system for the community of Harrisburg, Banner County (See Section 6.5 of this plan). This system will replace the present system that does not meet Health Department standards. The NRD has made application for FMHA funding and Banner County has made application for a Community Development Block Grant. Should funding be made available, the project will proceed.

1.2.7. Develop and Promote Educational Programs to Promote Public Support for Groundwater Management.

1.2.7.1. *Develop a summary brochure of GWMP.*

The I & E Specialist will develop this brochure after the GWMP is adopted.

1.2.7.2. *Develop an awareness of groundwater in school age children.*

The NRD has developed a number of educational programs including Water Wonders (a children's groundwater festival), booklets, and groundwater model displays. A nitrate and pesticide awareness program is planned.

1.2.7.3. *Expand adult citizen awareness of groundwater value.*

The NRD has promoted awareness through groundwater model displays, public meetings, speaking to clubs, civic groups and newsletters. With 319 funding, the I&E specialist has developed a periodic newsletter, "The Water Table," to be distributed to appropriate residents of the district. A brochure on the district activities will be developed in 1993. A display booth promoting NRD activities has been developed and presented at different functions such as county fairs around the district. A slide show on water quality efforts of the district will be produced in 1993.

1.2.7.4. *Provide technical information in cooperation with appropriate agencies or organizations to assist groundwater uses.*

This is now being done by NRD personnel on a request basis. With 319 funding, a professional will be hired by the Soil Conservation Service to provide technical assistance to landowners or operators on BMP implementation. Notice of the job opening has been given and the position should be filled during 1993.

1.2.7.5. *Support new legislation to obtain NRD jurisdiction of wells having less than 100 gpm capacity.*

LB 131, requiring registration of all new wells, was passed by the Nebraska Legislature in 1993 (See summary of this statute in Appendix 11.1 of this plan).

1.2.7.6. *Support legislation requiring well driller certification.*

The Water Well Standards and Contractors Licensing Act was passed by the Nebraska Legislature in the 1986 session. Sections 46-1201 through 46-1241 provide standards on the construction of wells as well as requiring licensing of contractors. The Nebraska Department of Health administers these programs.

1.2.8. Obtain Funding for Groundwater Management Purposes.

The NRD has consistently sought funding for groundwater studies and management programs from both State and Federal government agencies. Recent examples include cooperative study projects by USGS and CSD and the Water Quality Project Proposal which obtained Section 319 funding.

1.3. Review Letters on 1986 GWMP.

A. The 1986 GWMP was reviewed and approved by the following state agencies: DWR, NRC, DEC, DOH, CSD, and G & P. Any available review letters are on file at the NPNRD main office.

1.4. Documentation of Public Participation.

Any available documentation of public response to the 1986 GWMP (including public hearing agenda items, minutes, public comments, written comments, and correspondence) is on file at the NPNRD main office.

1.5. A General Description of the North Platte Natural Resources District.

1.5.1. General.

The NPNRD is located in the central region of the panhandle of Nebraska and includes the counties of Garden, Morrill, Banner, Scotts Bluff and the southern portion of Sioux County (Figure 12-1). The total area within the boundaries of the North Platte NRD is 5,124 sq. mi. Nearly all of the NPNRD lies in the North Platte drainage basin. There are six geographic sub-areas within this drainage basin. They are the North Platte Valley, Pumpkin Creek Valley, Northern Tablelands, Southern Tablelands, Wildcat Ridge, and the Sandhills. Bluffs and escarpments characterize the transition from valleys to the tablelands.

1.5.2. Climate.

The climate of the study area is characterized by extreme temperature ranges and low annual average precipitation, which is typical of a semi-arid, mid-latitude, continental setting. Mean annual precipitation is 15 to 18 inches (Figures 12-2, 12-3, and 12-4). Nearly two-thirds of the precipitation occurs during the growing season, which lasts from late May to late September. Precipitation in the study area is quite variable and typical of most arid, continental climates. Most of the precipitation occurs during thunderstorms in late spring and early summer. May and June are the two wettest months of the year. Potential evapotranspiration in the area usually is greater than precipitation.

Temperatures vary widely between summer and winter. July temperatures normally range from the 50's to the 90's and January temperatures from 10 degrees to 40 degrees. Based on records from 1951 to 1980 at the Scottsbluff weather station, the annual normal temperature is 48.5 °F, the maximum temperature in July is 89.3 °F, and the minimum normal temperature in January is 11.2 °F. The frost-free growing season averages about 130 days.

1.5.3. Drainage.

The North Platte River begins in the mountainous north-central part of Colorado with much of its flow originating as snow melt. The North Platte River generally flows northward to central Wyoming and then arcs to a southeasterly direction. In Nebraska, it continues to flow southeastward to its confluence with the South Platte river near the City of North Platte.

Snow melt runoff from the mountains is impounded by a series of on-stream reservoirs in Wyoming, and the stored water is released for irrigation. The released water is conveyed by canal through the basin for irrigation of cropland as far as 70 miles downstream from the Nebraska-Wyoming border. In most years, more water enters Nebraska via these canals than enters through the North Platte River channel.

Blue Creek, a tributary of the North Platte located in Garden County, rises in the Sandhills region in the northeast portion of the NRD and has perennial flow maintained by groundwater seepage. During the irrigation season, much or all of its flow is diverted into irrigation canals.

Inflow to the North Platte River from Pumpkin Creek, which enters from the south in central Morrill County, is much less now than it was under pre-development conditions. Rights have been granted to divert from the creek into small reservoirs and canals, including rights to pump directly from the creek. In recent years the creek has had no flow at its mouth at times in July and August, and as a consequence, the Nebraska Department of Water Resources has discontinued granting rights to divert water from Pumpkin Creek for direct irrigation purposes. Permits may be acquired for storage of water.

1.5.4. Hydrogeology.

Although the entire North Platte NRD is underlain by the massive High Plains Aquifer, there are four separate underground water regions within the NRD as described by E. C. Reed in 1969 (Reference 43). These regions are the Sandhills, Northern Tablelands, Southern Tablelands, and Platte River. A fifth region is also recognized in this plan as the Pumpkin Creek Valley.

The Sandhills Region includes the northern two-thirds of Garden County and the northeastern portion of Morrill County. This area is underlain by a significant thickness of saturated material consisting of Pleistocene deposits and Ogallala Group rocks. The dune sand absorbs precipitation readily and transmits much of it downward to the zone of saturation.

The North Panhandle Tableland Region is underlain by several hundred feet of sediments of Tertiary age, including the Ogallala Group, Arikaree Group, and the White River Group. The northeast portion of Scotts Bluff County, northwest-central portion of Morrill County, and the southern portion of Sioux County are part of this region. Moderate to large yields of water are available from most wells in this region.

The Platte River Region parallels the North Platte River throughout the NRD. The topography of this region is significant because of its scenic qualities, its intricate and partially revealed geomorphic history and the control it exerts on the hydrology. On the north valley walls of this region, a number of terrace surfaces have been identified in a vertical interval of several hundred feet. These represent a series of erosion and deposition cycles over millions of years that have deepened the North Platte Valley. The third terrace from the bottom, according to Wenzel and others (Reference 79), is of great importance because channels were cut into it to a depth of as much as 200 feet below the present flood plain. The channels were filled with sand and gravel, and they now constitute a productive source of groundwater. Areas north of the river which are located on the third terrace are Dutch Flats, Tabor Flats, Highland Flats, and Bayard Terrace.

The most productive wells for irrigation, industrial, and municipal supply draw water from the sand and gravel beneath the inner valley of the North Platte River or beneath the third terrace north of the river. Many of the wells yield as much as 1,000 gallons per minute.

High yielding wells can be obtained in the Pumpkin Creek Valley where the principal source of water comes from water-bearing fractures in the Brule Formation.

The remaining area in the NRD south of the Pumpkin Creek Valley is in the Southern Panhandle Tableland Region. Although this area is underlain by a fairly thick sequence of Tertiary formation, zones of saturated permeable rock are thick enough to yield adequate water for irrigation use only in localized areas.

1.5.5. Land Use.

The entire North Platte drainage basin is generally well suited for raising livestock and growing of feed and grain crops (Figure 12-5). Oil well development has been prominent especially in the western portion of the NPNRD.

Most of the NRD area has been recognized in numerous publications and studies for possible geothermal development. An effort was made in the early 1980's to drill a geothermal test hole in the Scottsbluff area near the Nebraska Western College.

A more recent development is that of uranium mining in the Nebraska Panhandle. Although the pilot plant is not located within the NPNRD boundaries, it has been recognized that areas in the NPNRD may have the potential for that resource. More discussion on these resources is included in Section 4.1.3 of this document.

2.0 Hydrogeologic Characteristics

2.1. Aquifer Description

2.1.1. General

An aquifer is described as any water-bearing stratum of rock or sediment capable of yielding supplies of water. The principal aquifer is the aquifer or combination of related aquifers and aquatards in a given area which is the most important economic source of groundwater for that area. (The principal groundwater aquifers in the NPNRD are shown in Figure 12-6).

A secondary aquifer may be any aquifer other than the principal aquifer that is not the main source of water to wells in a given area. Secondary aquifers may be perched or separated from an underlying body of groundwater by an unsaturated zone. The secondary aquifer may also be confined or artesian. An artesian aquifer is overlain by a low permeability layer. When the layer is penetrated by a well, pressure head will force water to rise above the aquifer in which it is contained. It is possible that perched and artesian aquifers, described above as usually being secondary aquifers, may be the principal aquifer in a given area. This concept will be discussed further in this Section.

2.1.2. Physical Characteristics

A series of exhibits have been prepared, based on existing maps and references, to identify groundwater reservoir characteristics as they occur in the NPNRD. The reader should refer to these exhibits as a visual aid when reviewing the following text discussion on the principal aquifer.

Figure 12-7 describes the physical characteristics of the various geologic units. Selected cross-sections in Figure 12-8 depict the subsurface relationships of the rock units in western Nebraska.

Figures 12-10 and 12-11 are water table contour maps showing the slope of the water table across the NPNRD. The general direction of groundwater movement is at right angles to the water table contours in the direction of greatest hydraulic gradient. The velocity of water moving through the aquifer is proportional to the hydraulic gradient.

Hydraulic conductivity of an aquifer system is the capacity of a porous material to transmit water under a unit hydraulic gradient through a unit area of the system measured at right angles to the direction of flow usually expressed in feet per day. If the pore spaces in the formation are large and well connected, such as in sand and gravel, the hydraulic conductivity is large. Conversely, if the pore spaces are small and not well connected, such as in silt and clay, the hydraulic conductivity is small.

Specific yield is the ratio of the amount of water a unit volume of subsurface material will yield, by gravity, divided by that volume. Values of specific yield for the NPNRD are shown on Figure 12-12.

Transmissivity is the rate at which water is transmitted through a unit width of the entire saturated thickness of an aquifer under a unit hydraulic gradient and can be expressed in thousands of gallons per day, per foot (Figures 12-13 and 12-14). Transmissivity can be computed by multiplying the hydraulic conductivity by the saturated thickness of the aquifer system. For example, in some areas the hydraulic conductivity may be large, but because the saturated deposits are thin, the transmissivity will not be great and the aquifer may yield relatively small quantities of water to wells. Conversely, if the hydraulic conductivity is small but the saturated deposits are thick, the aquifer may yield relatively large quantities of water to wells (Reference 6). The physical characteristics of each of the principal aquifers in the NPNRD are discussed in Section 2.1.2.1.

2.1.2.1. Principal Aquifers

The principal aquifers throughout most of the NPNRD are found in formations of Quaternary and Tertiary age with some exceptions (Reference 41). The top of the White River Group of the Tertiary system is considered the base of the aquifer system in most of the NPNRD (Reference 5). However, units within The White River Group are used as principal aquifers in several parts of the NPNRD. Figure 12-15 is a generalized map of the base of the principal aquifer.

The following is a discussion of each of the principal aquifers identified in the NPNRD in order of oldest to youngest in geologic age. Figure 12-6 indicates the approximate areal extent of each principal aquifer. Figure 12-16 illustrates groundwater in storage and Figure 12-17 shows the saturated thickness of the principal aquifer.

2.1.2.1.1. Chadron Formation

The Chadron Formation of Oligocene age (White River Group) is the oldest Tertiary stratigraphic unit in the NPNRD. It is believed to underlie most of the entire NRD with the exception of a small area in Banner County in T17N, R56-57W (Reference 93). Although mostly fine-textured (silty, sandy and bentonitic clays) a basal fine- to coarse-textured sand underlies the bentonitic clays locally in Banner County and rather extensively in Scotts Bluff, Morrill and Garden Counties (Figure 12-18). Chadron sands are believed to be as thick as 150 feet west of Broadwater in Morrill County (Reference 70A, Figure 5).

Water in the Chadron is under artesian pressure. It is considered to be a confined aquifer. Yields of wells tapping the Chadron sand range from only a few gallons per minute where the sand is thin or clayey to as much as 1,000 gpm in areas where the sand is thick and coarse grained. Smith and Souders (Reference 93) suggest "However, a water level drawdown of more than 200 feet and possibly as much as 500 feet would be necessary to maintain the yield of 1,000 gpm." Water in the Chadron formation is rather highly mineralized and is of the sodium-bicarbonate type. There is minimal information available on the hydraulic properties of Chadron Sand. The geometric mean hydraulic conductivity was calculated at 8.5 ft/day, (application to DEC for Crow Butte Uranium Project, Wyoming Fuel Co.). The value of transmissivity will vary with hydraulic conductivity and according to the saturated thickness of the formation. Discussion later in this text will focus on some of the past problems encountered with groundwater from the Chadron Sands.

Of some importance to the NPNRD is the fact that uranium is being mined from the Chadron Sand near Crawford. Previous research indicates that the Chadron Formation near the Crawford uranium mining area is the same formation found in the NPNRD (Reference 84) (Figure 12-18).

2.1.2.1.2. <u>Brule Formation</u>

Much of the Brule Formation consists of clays and silts and has minimal hydraulic conductivity. However, some channel sandstones and fractures exist in portions of the Brule Formation of the White River Group. Economic yields of groundwater may be obtained especially where saturated fracture zones occur. Overlying Quaternary deposits such as alluvium and dune sand generally have high hydraulic conductivity and allow water to percolate down into the fractures of the Brule Formation (Reference 5). The same can be true in cases where the Brule is overlain with the Ogallala Group of the Tertiary age.

The fractures in the Brule transmit sufficient water for irrigation both north and south of the North Platte River in Scotts Bluff and Morrill Counties and along Pumpkin Creek in Banner County. The main sources of water supply in the Pumpkin Creek Valley in Banner County and in the outer portions of the North Platte Valley are from the fractures and perhaps from channel fill deposits in the Brule formation. The Conservation and Survey Division is currently investigating these features of the Brule Formation to determine their extent and hydraulic behavior.

Where the Brule contains fractures but is so situated that the water supply cannot be maintained by drainage from surrounding unfractured Brule or overlying sediments, yields of wells tapping this stratigraphic unit may diminish seasonally. Thus, some irrigation wells that are pumped heavily in the early weeks of the growing season are incapable of yielding sufficient water later in the season (Reference 93).

Many of the hydraulic properties of the Brule, such as transmissivity (T), are difficult to describe because of the existence of the fractures in the otherwise tight impermeable formation. Values of T range from approximately 10,000 to 100,000 in fractured areas of the Brule according to Smith and Souders, 1975, (Reference 93). The potential for well yields would be 100 gallons per minute to 1,000 gallons per minute respectively.

The hydraulic conductivity in the unfractured Brule Formation is less than 25 feet per day (Reference 6), however, it is much higher in areas where the fractures exist in the Brule. Wenzel and others (Reference 79) calculated the field coefficient of permeability of the Brule and the values ranged from 243 to 889 with an average of 573. A coefficient of 573 means that the formation will transmit 573 gallons of water a day through each strip of the formation one mile wide and one foot thick for each foot per mile of hydraulic gradient.

To simplify this expression, the coefficient of 573 is equal to 75 feet per day. In contrast to these relatively high values, Wenzel and others also report that two samples of typical Brule from the Scotts Bluff monument had coefficients of permeability of 4 and 7.

In the same study they also calculated the average specific yield to be 29.6%. However, they concluded that because of the tight character of the Brule, it yields water sluggishly and several months to a year or more are required before the specific yield calculated in the laboratory is reached. As a result the quantity of water that is removed from storage by a decline of the water table in the Brule cannot be calculated from the specific yield determined in the lab unless the water table remains below the material for a long period.

The depth to the water table generally is less than 50 feet below the ground surface in most of the Pumpkin Creek Valley. (Figure 12-19). The saturated thickness of the entire formation may be little more than 100 feet. The saturated thickness lying above the fractures may be more meaningful because it would be a source of recharge to the Brule and that information is unavailable at this time.

2.1.2.1.3. Arikaree Group

The Arikaree Group is the next younger stratigraphic unit after the Brule Formation. The Arikaree Group is exposed extensively on the slopes separating the floor of Pumpkin Creek Valley from the Cheyenne Tablelands on the south and the Wildcat Hills Ridge to the north. It is also exposed along the north slopes of the North Platte Valley and is the principal aquifer in the northwestern region of the NPNRD, particularly in Sioux County. Sandstone, mostly very fine to fine grained but in small part medium grained, is the principal constituent of the Arikaree. Silt, siltstone, and volcanic ash make up most of the remainder (References 70, 93 and 94). See cross sections in Figure 12-8 for thicknesses of the Arikaree in the subsurface.

Most sandstone beds in the Arikaree are so fine textured that they are only slightly to moderately permeable. However, where the saturated thickness is 100 feet or more, wells yielding sufficient water for irrigation generally can be obtained, but the longevity of such yield may be limited. Pumping of sand with the water is a potential problem unless the well is equipped with an appropriate gravel pack and screen of proper slot size to prevent sand entering the well (Reference 93). A map of Morrill County (Reference 69) shows the area where wells of more than 200 gpm might be obtained from the Airkaree Group.

Because the permeability of the consolidated sediments of the Arikaree is relatively low, the water does not percolate through it to wells as fast as the water is withdrawn, even though the pumping rate may be quite low. Subsequent pumping will cause the water level to drop and it will recover only after a considerable period of idleness (Reference 79). It should be recognized that in regions just beyond the northern boundary of the NPNRD, near Alliance, accelerated development of groundwater for irrigation is causing a local progressive decline of the groundwater level because withdrawals exceed recharge to the zone of saturation. Although a tremendous quantity of groundwater is stored beneath this area, withdrawals at the same or greater rate will cause further decline of groundwater levels and increase pumping costs (Reference 43). These facts are important for the NPNRD to consider since the groundwater reservoir in the northern part of the NPNRD is very similar to the reservoir which occurs in the southern portion of the Upper Niobrara White NRD.

The specific yield in the Arikaree ranges from 5 to 10% in Banner County to approximately 15% in Sioux County (Figure 12-12). However, these values are believed to be low and are more likely in the range of 18 to 25% in the long term. The hydraulic conductivity is generally 100 to 300 ft/day or less and, depending on aquifer thickness, values of transmissivity range from less than 20,000 to as much as 50,000 gallons per day per foot as shown in Figure 12-13.

2.1.2.1.4. Ogallala Group

A narrow band along the southern boundary of the NPNRD is known as the Cheyenne Tablelands. The Ogallala Group of Tertiary age is the most important water-bearing stratigraphic unit underlying the Cheyenne Tablelands of southern Banner, Morrill and Garden Counties and small areas of eastern and northeastern Morrill County and parts of northern Garden County (References 93 and 94). It should be noted that the Ogallala aquifer in this discussion includes younger units such as the Broadwater Formation and other sediments of similar nature.

The Cheyenne Tableland is underlain by the Ogallala Group which ranges from 45 to 540 feet in thickness. It is composed of gravelly sand, sand, siltstones, and clay. The Ogallala has a higher average permeability than the Arikaree and Brule and therefore yields water to wells more freely than an equivalent thickness of Arikaree or Brule. The depth to groundwater is generally 100 to 200 feet from the surface and as much as 300 feet below the surface near the southern boundary of Banner County (Figure 12-19). Based on test holes of a previous study (Reference 93) only a relatively small part of the total volume of the Ogallala sediments is saturated. Values of transmissivity (T) range from less than 50,000 to 100,000 in most of the tablelands which would indicate well yields of 1,000 gallons per minute. The potential for larger yielding wells (2,000 to 3,000 gallons per minute) exists along a narrow stretch along the southern boundary of Banner County (Figure 11 in Reference 93).

2.1.2.1.5. Sandhills Aquifer

The Sandhills Aquifer, as delineated in Figure 12-6, is similar to the Ogallala in having high transmissivity and specific yield. It is, however, necessary to differentiate between the Sandhills Aquifer and the Ogallala because of the different topographic features and subsurface structure of the Ogallala in the Sandhills. The Sandhills Aquifer is most predominant in northern Morrill and Garden Counties and in a small area southwest of Bridgeport (see Figure 12-6).

This region of the NPNRD is on the western edge of the massive sandhills of north-central Nebraska. Typical of this region are grass-covered sand dunes, relatively flat interdune meadows, many small lakes and large areas having no surface drainage. The sandy soils readily absorb precipitation and transmit it downward to the zone of saturation, so overland runoff rarely occurs. The Ogallala of Tertiary age underlies much of the area with fluvial deposits of Pleistocene or Pliocene sand and gravel filling channels eroded into the surface of Ogallala. These relatively young materials of Quaternary age are, for this report, combined as a Quaternary unit. The principal hydrologic importance of this unit is its ability to absorb precipitation and transmit it downward. In places, large yields could be obtained from wells of moderate depth tapping the Pleistocene or Pliocene sand and gravel while elsewhere large yields generally could be obtained from deeper wells tapping permeable beds in the Ogallala. Despite the tremendous potential for large-yield wells, only a small amount of groundwater is being withdrawn at the present time from the Sandhills aquifer.

2.1.2.1.6. Alluvium

Highly permeable sand and gravel of Quaternary age occur as thick deposits of water-bearing material beneath the bottom lands along the North Platte River, beneath the parts of the lower terraces north of the river and in the bottomlands along Pumpkin Creek in Morrill County. Much of the alluvium, and perhaps all, is considered to be recent in age.

These deposits constitute the fill in old channels that the North Platte and its tributaries cut in the Brule Formation during the later stages of the development of the valley. Deposits of sand and gravel are found as general cover on the upper terraces north of the river, and in most cases, are much thinner than the channel deposits. The thickness of the fill in channels is as much as 200 feet, whereas the mantling terrace deposits are mostly less than 20 feet thick. See Figure 12-6 for the areal extent of the alluvium.

Wells that draw water from the sand and gravel in the old channels commonly yield 800 to 1000 gallons per minute or more. Many wells pumped for irrigation, industrial and municipal supply tap this productive channel fill along the bottomlands of the North Platte River or on the lower channel filled terraces north of the river.

The hydraulic conductivity in areas adjacent to the North Platte river is in excess of 300 feet per day, and may range as high as several thousand feet per day expressed in Meinzer units. Values of transmissivity (T) range widely from 20,000 to more than 500,000 gallons per day per foot and corresponding wells yield as much as several hundred to several thousand gallons per minute. Refer to

Figure 12-12 for values of specific yield and Figures 12-13 and 12-14 for values of transmissivity. Figure 12-13 is a generalized map of T, and Figure 12-14 is a detailed map of T in the North Platte River Valley. The wide range of T as illustrated in the latter figure is due in part to thicknesses of water saturated material, but is largely due to the range in coarse aggregate texture. There are some very interesting and complicated relationships between the extensive surface water irrigation system and the groundwater that exist in the alluvium of the North Platte Valley. These relationships are further discussed later in this section under Groundwater/Surface Water Relationships.

2.1.2.2. Potentiometric Surface

2.1.2.2.1. Unconfined Conditions

The first map showing the configuration of the water table in a part of the NPNRD was published in USGS Water-Supply Paper 943, 1946 (Reference 79). The map of Scotts Bluff County and a small portion of Sioux County was based upon measurements of water levels in about 340 wells. Weekly measurements were made from July 1937 to August 1938 in about 45 of the wells. Three of the wells were equipped with automatic recorders. Altitudes of the measuring points of the wells were determined by altimeter; presumably the altitude of streams, drains, and springs were from a topographic map (Plate 1 of the report) with a contour interval of 20 feet. A detailed discussion of the fluctuations of water levels in wells in the study area was given (pages 89-106). Fluctuations of water levels are related to surface water use and storage, to precipitation, to changes in flow of the North Platte River, to groundwater withdrawal, to changes in barometric pressure and to evapotranspiration (pages 116-118).

The map of the water table in the 1946 USGS report represents November, 1937 conditions and, as suggested by the authors, may, in part, represent the piezometric surface. The 1937 map compares favorably with maps prepared in more recent years. Although changes in water management and use have occurred since 1937, the conditions as described by Wenzel, Cady and Waite of groundwater in storage probably has not changed materially some 55 years later.

A map showing the configuration of the water table of the Dutch Flats area of southwestern Sioux County and northwestern Scotts Bluff County was published in 1951 as USGS Circular 126 (Reference 81). The map, with 10 foot contour intervals, represents September, 1949 conditions. Ground altitudes were established by an instrument survey.

Maps depicting the configuration of the water table in the fall of 1971 for the Scottsbluff and Alliance 1:250,000 quadrangles were published in 1975 (References 37 and 38). Contour intervals were 50 and 100 feet and the two maps cover all of the NPNRD (Figure 12-10). The authors, Souders and Freethey, include a reliability diagram rating the accuracy of various parts of the map as good (±10 foot accuracy), fair (±25 foot accuracy), and poor (±50 foot accuracy).

A report on Banner County (Reference 93) published in 1975 includes a map showing the configuration of the water table, which represents winter of 1972-73 conditions. The contour interval for this map is 100 feet. A more detailed map with 50 foot contours was prepared for Morrill County, 1982 (Reference 70A). The Conservation and Survey Division, UNL, also published a map of the water table in Pumpkin Creek Valley in 1979 (Reference 48).

The Nebraska Department of Water Resources and the North Platte NRD cooperated in the scheduling and mass measurement of about 356 wells in the North Platte River Valley. Spring and Fall measurements were made over short intervals of time in 1986-1988. Jim Cannia, NPNRD, prepared water table contour maps on individual 7.5 minute topographic maps using the spring, 1987 water level data. Altitudes of the measuring point of each well were determined in the field from the topographic maps, mostly 10 foot contour intervals. A few maps have 20 foot contours and others in the river valley have supplemental 5 foot intervals. Points of live streams and drains were considered to be groundwater intersect points. Data, for the most part., was judged adequate to allow for the preparation of a map of the water table with 20 foot contours (Figure 12-11).

The water table is considered to represent unconfined conditions and is considered to be the upper surface of the first saturated rocks encountered below the land surface. Locally, stratification of fine and course grained sediments (low and high permeability) may permit slightly different water levels in wells screened at variable depths, particularly in areas where groundwater is being recharged or discharged at relatively rapid rates.

Geology exerts significant influence on the configuration of the water table. Groundwater moves toward discharge areas through the fine grained rocks of the Brule Formation in many places in the NPNRD. The Brule also occurs as buried bedrock knobs and ridges in the valley. The more closely spaced contour lines in some areas indicate steep hydraulic gradients due to these rocks of low permeability. The contour lines along the bluffs and escarpments of the valley show very steep hydraulic gradients of up to several hundred feet per mile. It is probable that the water table in some places may not be continuous with the water table in the valley so the actual conditions may be somewhat different than depicted.

In Scotts Bluff County (Reference 79), the authors estimate that the hydraulic gradients of the water table in the Brule Formation average about 50 feet per mile, and in the alluvium the gradients average only about 7 feet per mile along the North Platte River.

The configuration of the water table is changing continuously and a water table map completed at any one time represents conditions only at that time. Water table maps that have been prepared to date represent only approximate conditions in much of the area. In general, the quality of the maps is good for the valley portion of the NRD. Because of rapid changes within short distances due to the complexity of the geology and topography, and the way both surface and groundwater are used in the NPNRD, detailed maps would require the acquisition of an extremely large data base. The cost of the acquisition of such a data base is prohibitive except perhaps to address a particular localized problem. An example of this type of effort is illustrated by an investigation by the NPNRD in an area from Lewellen to west of Oshkosh in Garden County. The investigation is related to the occurrence of some high levels of nitrate-nitrogen in the Oshkosh area. About 86 wells have been scheduled in all or parts of eight townships. Water levels were measured in 1992, and will be repeated until the investigation is completed.

The water table maps show the direction of groundwater movement, which is at right angles to the contours. Groundwater throughout the NPNRD is moving toward discharge areas, i.e. the North Platte

River, its tributaries, springs, drains, lakes, and shallow water table areas where water is discharged by evapotranspiration. In much of the NRD the movement is toward discharge in the North Platte River Valley. Groundwater contours in the northern part of Morrill County indicate that movement is toward the northeast into Box Butte County and to discharge in the lakes and wetlands area. Groundwater in about the northern half of Garden County is slowly migrating east-southeast toward discharge in the wetlands and lakes largely by evapotranspiration. In the southern part of Garden County north of the North Platte River, groundwater movement is toward the valley and to Blue Creek (some moves eastwardly across the county line). The geologic cross sections in Morrill County (Reference 70A), and Banner County illustrate the water table in profile.

Currently there are about 143 active observation wells being measured as part of the cooperative program of the NPNRD, the U.S. Geological Survey and the Conservation and Survey Division, UNL (Table 2.1.2.2.1-1 and Figure 12-20). Twenty two of the wells in northern Garden County are being measured seasonally by staff of the Crescent Lake National Wildlife Refuge. Many additional wells have been measured, some since the early 1930's. Some wells have single or short term records, others were measured for many years, but are no longer being measured for various reasons including well destruction, abandonment and access.

Table 2.1.2.2.1-1

OBSERVATION WELLS

	Type of Measurement			
County	**Semiannual**	**Seasonal**	**Recorder**	**Total**
Banner	19	0	2	21
Garden	10	22	0	32

Morrill	27	3	1	31
Scotts Bluff	35	0	1	36
Sioux	22	1	0	23
Total:	113	26	4	143

Since about 1986, the NPNRD has assumed an active role in planning, measuring and maintaining the observation wells. A number of wells have been added to the network in the last few years. The number of wells in the network and the length of their records permits only general evaluations of groundwater level trends. Evaluation of water level changes has been done in some of the reports mentioned previously in this section. Annual reports published by CSD in cooperation with the US Geological Survey have contained information about water level changes. Staff of CSD in the Scottsbluff office have at various times in the past prepared open file reports in which water level changes in the NPNRD have been evaluated. In general, NRD-wide, significant water level changes do not appear to have occurred over the last 50 or 60 years. Dramatic changes in the water table did occur during the early years of surface water development as noted and discussed by Wenzel, Cady, and Waite (Reference 79). Data to prepare a pre-development water table map in the North Platte River Valley is sparse to non-existent. Available information suggests that water levels had adjusted to recharge conditions, resulting from the transportation, storage, and use of surface water, by the 1920-1930 period. Locally, however, and particularly in areas not being affected by surface water development, unconfined water levels have reflected both groundwater withdrawal and climatic conditions, notably in Pumpkin Creek Valley. Hydrographs of some observation wells selected to illustrate varying conditions in the NRD are presented in Figures 2.1.2.2.2-1, 2.1.2.4.1.1-1, and 2.1.2.4.1.3-1.

2.1.2.2.2. Confined Conditions

Groundwater is either known or suspected to occur under confined conditions in a number of bedrock units in the NPNRD. They are the Dakota Group, the Transition Zone of the Pierre Shale, the Fox Hills formation, the Lance Formation and the White River Group. The White River Group includes the Chadron Formation, possibly the most important of the confined aquifers, and the Brule Formation. In places the Orella Member of the Brule contains some alluvial sediments in which water is probably confined. A generalized description of these geologic units and maps showing their occurrence is contained in "Cenozoic Paleogeography of Western Nebraska" (Reference 84). Information about the potentiometric surface before oil or water wells were drilled into any of the units is quite meager, as is information concerning the potentiometric surface at this time.

Several articles in Reference 169 report on the geohydrology of the "Dakota Aquifer". Some apply to the panhandle of Nebraska. One article, "Regional Study of the Dakota Aquifer", discusses the complexity of the Dakota Aquifer System and includes a generalized map showing potentiometric contours across the NPNRD which range from about 3,000 feet above sea level near the stateline to less than 2,000 feet near the east NRD boundary. A work map showing more detailed contours of the potentrometric surface in western Nebraska has been prepared by H.M. DeGraw, CSD (Oral Communication, 1993). The map, based upon reported results of drill stem tests, indicates a rather complex surface with the surface ranging from about 1,200 feet above sea level to slightly more than 2,000 feet. No distinct trend from west to east is evident. Little, if any, information is known about the potentiometric surface in the Transition Zone, Pierre Shale. The zone of shale and sandy shale contains some very fine grained sandstone. This zone, in the upper part of the Pierre Shale, occurs in parts of Scotts Bluff, Sioux, Banner and Morrill Counties (Reference 84). None of the logs of registered wells used as a water source for oil or gas well flooding in the NPNRD suggest that wells in the transitional Pierre have been constructed. H.M. DeGraw reports that at least one well in this zone in Kimball County was used as a water-flood well, but that the yield was very low (Oral Communication, 1993). Five wells that tap the upper Pierre Shale or the Transitional Zone of the Pierre in Banner County were reported by Smith and Souders (Reference 93). No water levels are reported, although one well in 18N-53W-6DA is reported to be a flowing well.

Information with respect to the potentiometric surfaces in Lance and the Fox Hills Formations is also meager. No wells in these formations are reported in Banner County by Smith and Souders. Wenzel, Cady and Waite (Reference 79) inventoried 33 flowing wells in Scotts Bluff County. Most of the wells were in the Lyman area and were thought to be constructed in the Lance Formation. Two wells at Gering were also considered to have tapped the Lance and three wells south of Mitchell were considered to have tapped water under artesian pressure in the Brule. No information on the heads was obtained. Some of the wells that initially flowed at the surface were pumped, and at least one stopped flowing by 1936. At least some, and probably most of the wells, were actually completed in the Chadron Formation rather than in the Lance or Fox Hills Formations.

The Chadron Formation is the principal confined aquifer in the NPNRD that has been and is being used as a source of water for various purposes. The extent and thickness of the Chadron Formation is illustrated in the "Cenozoic Paleogeography of Western Nebraska" (Reference 84) reproduced here as Fig. 12-18. Smith and Souders in the Banner County report (Reference 93) discuss pressures in the Chadron Formation with reference to the Horseshoe

Bend area in northeastern Banner and southeastern Scotts Bluff Counties (see discussion in section 6.2 of this plan). A detailed discussion of the Chadron potentiometric surface in the Horseshoe Bend area is contained in the transcript testimony presented by V.L. Souders (Reference 170) at the time of the hearing for a Groundwater Control Area, 1976.

A hydrograph of observation well 20N-53W-26ABA in Banner County (Figure 2.1.2.2.2.-1) illustrates changes in the potentiometric surface of that well resulting from use of water. Souders, 1976, reports that a domestic well in 20N-53W-18AAB Scotts Bluff County initially had a "water level" of 14 feet when drilled in 1957. The depth of the well is 510 feet and is completed in the Chadron sand. The "water level" (or head) had dropped to about 120 feet when he started measuring the depth to water, July, 1972 and later in September, 1973 the water level dropped to about 180 feet. It recovered later to about 145 feet in mid October, 1973. The two wells (Sections 18 and 26) are about four miles apart and the ground altitude of the Scotts Bluff County well is about 3,970 feet above mean sea level (msl), and the Banner County well is about 3,919 feet above msl. The latter well is reported to have flowed at the surface from 1956 to 1959, indicating a potentiometric surface of approximately 3,922. Since 1974 the potentiometric surface has ranged from below 3,720 to near 3,620 feet above msl (Figure 2.1.2.2.2-1).

Souders, 1976, prepared a map showing reported and measured potentiometric surfaces in 12 wells in T20N-R53W, Banner and Scotts Bluff Counties. He stated that prior to 1973, and before any irrigation wells were drilled in the area, there probably had been a head loss in excess of 40 feet in Horseshoe Bend area.

Wells have been completed in confined aquifers elsewhere in the North Platte River Valley in Morrill and Garden Counties. A complete inventory of wells completed in the Chadron Formation or other older confined aquifers is not available.

2.1.2.3. Flow Direction

The groundwater flow direction is indicated by the water table contour map, Figure 12-10. Flow direction is at right angles to the contour lines.

2.1.2.4. Significant Discharge Areas

Some discussion of groundwater discharge is contained in the previous sections on the potentiometric surface. A detailed description of groundwater discharge is contained in Reference 79 in which Wenzel, Cady and Waite discussed conditions in Scotts Bluff County. That information, in general, applies to much of the NPNRD. The significant discharge areas are: the North Platte River Valley; the Sand Hills portion of Morrill and Garden Counties; Pumpkin Creek Valley; the North Platte River, its tributaries and drains; and areas of groundwater withdrawal by wells for irrigation, public water supply and industrial use (see Section 5 on water use). By far, the greatest quantity of groundwater discharge is to the streams and drains and to evapotranspiration (ET) from the zone of saturation. The quantity of water discharged from water or wet surfaces and the capillary fringe is difficult to quantify. Wenzel, Cady and Waite estimated the discharge of groundwater from lands where the water table was near the surface to be about 18 inches per year in Scotts Bluff County. They estimate that evapotranspiration loss in Scotts Bluff County alone was about 100,000 acre-feet per year (pp 118 and Figure 12, pp 117, Reference 79). If evaporation from water surfaces supplied by groundwater is added to the ET loss estimated by Wenzel, Cady and Waite, a conservative estimate of groundwater discharge from ET in the NPNRD is at least 300,000 acre-feet and could be as much, or more, than 500,000 acre-feet.

2.1.2.4.1. Groundwater/Surface Water Relationships

2.1.2.4.1.1. North Platte River

Groundwater and surface water in the North Platte River Valley are now intimately related along the inner valley (i.e. floodplain) and on the terraces below the myriad of irrigation canals and laterals. Prior to the advent of surface water diversion for irrigation, the potential for developing large capacity wells of more than several hundred gallons per minute was probably confined to the area with a rather narrow band of high transmissivity (more than 100,000 gallons/day/foot, Figures 12-13 and 12-14). For the most part, the area with the high transmissivity occurred along a deeply incised (up to 200 feet deep) channel cut into the Brule or older bedrock. The channel is narrow, being generally one to three miles wide, although it splits into two channels in Scotts Bluff County with one channel extending into the southwest corner of Sioux County. Surface water diversion and use has resulted in saturating previously unsaturated sand, gravel and the Brule Formation and providing a relatively abundant source of groundwater now discharged by stream tributaries, drains, evaporation, transpiration and wells. The size of areas now capable of supporting medium and large capacity wells has increased and the supply has become reliable.

The amount of water going into storage is substantial but has not been quantified. Wenzel, Cady, and Waite (Reference 79) estimated that water levels had risen as much as 50 feet in Scotts Bluff County by the late 1930's. The literature and other available information suggests that a new equilibrium between natural recharge and recharge from surface water use and groundwater discharge was attained in the valley by the 1930's.

Changes in water levels and variations in the amount of water in storage occur seasonally in response to precipitation and diversion from storage reservoirs.

Wenzel, Cady, and Waite (Reference 79) discuss and emphasize the impact of seepage from surface irrigation in Scotts Bluff County in recharging the groundwater supply. They observed that fluctuations of water levels and changes in groundwater storage due to seepage obscured other factors causing changes, such as precipitation, underflow and groundwater withdrawal. Water levels rose as much as 13.5 to 23 feet in one season around Lake Minatare and the average seasonal rise of 20 wells affected by seepage from canals and irrigated fields was six feet in 1937-38. Water levels in wells affected by surface water use reach their lowest levels in mid-year, rise during the irrigation season, and start declining in the latter part of the year. The hydrograph of the Scottsbluff recorder well (Figure 2.1.2.4.1.1-1) illustrates that condition. The well is about one half mile north of Scottsbluff, about 500 feet north of the Enterprise Canal and about three miles north of the river. The amount of seepage along this canal and others and that impact on groundwater levels is variable and dependent on local hydrogeologic conditions, amount of flow in the canal, and length of time water is in the canal. Water levels in wells not affected by seepage from surface water irrigation generally are the highest in the spring and lowest in the late summer and fall.

Wenzel, Cady, and Waite also noted in Scotts Bluff County that the smallest fluctuations of water levels were observed in wells close to the North Platte River and in those areas not affected by irrigation with surface water. The river, tributaries, drains and wetlands control the rise of water levels. The relationship of surface water and its use to groundwater is probably similar elsewhere in the NRD to that described by Wenzel, Cady, and Waite for Scotts Bluff County. The close relationship has become established over a period of almost 100 years and remains essentially unchanged. The balance in use of water from surface or underground sources that has been achieved is largely dependent upon the amount of water available from storage of water in the North Platte River. The impact of groundwater withdrawal on availability of water in the valley is small compared to surface water use and is probably not measurable.

The balance in water supply that has been attained could be adversely impacted by management policies making less water available for diversion. Lining of canals could also adversely impact the present balance. Additional storage, utilizing both surface and subsurface storage, could, on the other hand, result in a more uniform annual supply.

The North Platte River is both a gaining and losing stream, dependent upon the stage of the river. During high flow stages, the water surface rises above the water table at its banks. Water percolates out of the river into the ground until the adjacent water table rises to a level approximately corresponding to the stage of the river. When the river stage lowers, adjustment occurs and water percolates back to the river. In Scotts Bluff County, Wenzel, Cady, and Waite (Reference 79) observed a well near the river through March and June, 1938 and showed a close correlation of the water level to the river discharge. River discharge ranged from about 200 cfs to about 1500 cfs. Water levels corresponded very closely with discharge and the amount of change was slightly more than one foot. The distance away from the river that water levels are affected depends upon the length of time that a river stage is maintained. Wenzel, Cady, and Waite suggest that a small rise or fall in the stage of the river produces a change in water levels for a mile or more from the river.

2.1.2.4.1.2. Pumpkin Creek

Water table contours generally decrease in altitude towards Pumpkin Creek (Figure 12-11). Groundwater moves in directions of the maximum slope of the water table, or at right angles to the water table contour lines. If not intercepted by pumping from wells, groundwater eventually reaches an area where it issues from springs and seeps back into the ground or is discharged by vegetation uptake, direct evaporation to the atmosphere, pumping from wells, or seepage into stream channels (Reference 93). If the groundwater does not discharge by some means to the surface it may leave the drainage region as underflow.

Pumpkin Creek is shown on the 1898 USGS maps as a perennially flowing stream. However, on the 1954 and later editions of the U.S. Geological Survey's Scotts Bluff quadrangle, it is shown as intermittent throughout its full length in Banner County. Losing reaches of the creek could be caused by water percolating down into fractures of the Brule and alluvial deposits along the creek. Pumping stresses may also create or accent losing reaches of the creek by intercepting groundwater that otherwise would have seeped into the stream channel (Reference 93).

The above phenomena regarding the cause of losing reaches in Pumpkin Creek are further substantiated by a series of infrared areal photos taken of Pumpkin Creek by the NPNRD from 1980 to 1984 (Reference 56). The photos indicate that rather long stretches of flowing water in Pumpkin Creek during early spring later progressively declined to virtually no flowing water in the stream by fall of the same year.

The apparent losing reaches are in the vicinity of Wright Gap and between Lawrence Fork and Middle Creek. Previous water level measurements indicate the water levels were below the bed of Pumpkin Creek from about 1.5 miles downstream from the mouth of Lawrence Fork to just above the mouth of Middle Creek. There may be other losing reaches, but due to lack of reliable data, the above named reaches are the only areas delineated at this time (Reference 100).

2.1.2.4.1.3. Sandhills Lakes Area

The natural lakes in northeastern Morrill County and the northern one-third of Garden County are among the most distinctive features of the Sandhills portion of the NPNRD. Their presence is somewhat surprising considering the prevailing climate of the region, which ranges from subhumid to semiarid. These lakes, located in interdunal valleys, tend to be broad and shallow, rarely exceeding a maximum depth of 10 feet. In the absence of detailed information concerning the hydrology and hydrogeology of these lakes, observations about their nature have usually been stated in general terms.

Infiltrating precipitation is eventually returned to the atmosphere by transpiration of the vegetation and evaporation from the lakes.

The remainder is discharged as streamflow. Some of the lakes are hydraulically continuous with the zone of saturation. Those streams heading in the sandhills area are noted for consistency of base flow due to groundwater seepage.

Because surface runoff is limited by the high permeability of sandhills soils, the majority of these lakes are commonly assumed to be maintained by groundwater sources. However, this assessment may be an oversimplification. Although the associated hydrology has not been rigorously studied, a study by Buckwalter, CSD 1983, (Reference 101), seems to indicate that the hydrologic characteristics of the lakes are quite diverse. These characteristics include net evaporation loss, water quality, degree of hydraulic connection with the saturated zone, and degree of seasonal fluctuation in size. Comparisons of temporal imagery from infrared photos illustrate the persistence of some lakes and the ephemeral nature of others. The study points out that water quality varies from fresh to strongly saline and alkaline brines. While the majority of lakes are generally thought to receive inflow from groundwater, others may be sealed off from the regional zone of saturation and largely supported by surface runoff.

This situation could result in lakes with relatively high salt concentrations whose surface levels fluctuate independently of the water table. Water levels of lakes in hydraulic connection with the saturated zone fluctuate in unison with the water table and, presumably, maintain lower salt concentrations through dilution by rapid interchange of water between the lakes and groundwater.

Some of the Sandhills lakes of Morrill and Garden Counties were inventoried, discussed and sampled for water quality by McCarraher, 1977, (Reference 159). McCarraher found a wide range of total dissolved solids and pH in nearby lakes. For example, Border Lake near the center of T21N, R45W in Garden County had total salinity [mg/l Total Dissolved Solids (TDS)] of 78,000 with a pH of 8.5. Near the northwest corner of the same township, Alkali Lake had 66,300 mg/l TDS and a pH of 10.8. To the south in T20N, R44 and 45W Swan Lake had 465 mg/l, pH of 8.9; Blue Lake 330 mg/l, pH of 8.4; and Crescent Lake 342 mg/l, pH of 9.5. Springs at the head of blue Creek have been sampled and the TDS was 214 mg/l.

More research is required concerning the hydrogeology of the Sandhills lakes to investigate the geologic and climatic influence on their occurrence and behavior, and to better explain the variation in water quality and the complex geochemistry of the water. Some investigation has been done in the "Blue Creek Basin" portion of Garden County (James Swinehart, CSD, personal communication 1993) and more is planned. Other research by CSD underway to the north in southern Sheridan County could have an application to Sandhills lakes in the NPNRD (Reference 160). Winter, T.C., USGS (Reference 161) has also studied Sandhills lakes.

There are currently only about 12 registered irrigation wells in the Sandhills lake portion of Morrill and Garden Counties. Intense groundwater withdrawal could have various impacts on the lakes and associated wetlands. About 22 wells have been monitored since 1933 and 1934 in the Crescent Lake Migratory Bird Refuge in north central Garden County. The hydrograph of the Crescent Lake well (Figure 2.1.2.4.1.3-1) shows no distinct water-level change trend since the drought of the 1930's.

9.

2.2. Aquifer Vulnerability Description

2.2.1. Surficial and Vadose Zone Description

2.2.1.1. Topography

A map (Figure 12-21) shows the location and name of each of the 7.5 minute quadrangles in the NPNRD. The NPNRD has and maintains sets of these maps for field and office work. The Scottsbluff and Alliance quadrangles, scale of 1:250,000 also cover the NRD. Topographic relief is considerable within the NRD and ranges from very steep on the North Platte River Valley sides to relatively gentle in the valley itself, and in the uplands. Generalized to detailed slope maps have not been prepared and would have minimal value. The soils maps (generalized and detailed), the geologic maps, and land use maps all reflect slope and the percent slope for each soil type is given in the published county soil surveys.

2.2.1.1.1. Natural Recharge Areas and Rates

All areas in the NPNRD can be considered as natural recharge areas to some degree. Obviously, recharge on vertical or steeply sloping bedrock outcrops is negligible.

An aquifer can be recharged through natural processes or though artificial means. The source of natural recharge is primarily the precipitation that falls directly on the land. Runoff from the land concentrates in valleys and canyons where significant infiltration occurs. Quantification of the amount of natural recharge is difficult for even small geographical areas. Estimates of average annual recharge are usually based on certain assumptions including average annual precipitation, soil characteristics, land slopes and soil cover, transmissivity, and configuration of the water table.

Regional estimates of recharge are still very difficult due to the local variations in geology, soils and topography. Of particular importance to the NPNRD is the precipitation originating as snow and ice melt outside of Nebraska that contributes to groundwater recharge in the North Platte Valley. The snow and ice melt are the primary source of water for the extensive surface water irrigation system in the North Platte Valley. More discussion on the recharge of the groundwater from the irrigation systems is included in the subsection of surface water/groundwater interactions for the North Platte River. It is difficult to separate the discussions on recharge and stream/aquifer relationships because they are so closely related to one another especially in the North Platte River Valley.

In previous studies concerning the North Platte Valley (Reference 79) it has been recognized that there are rises in the water table caused by penetration of rainfall to the zone of saturation, seepage from the North Platte River, and by underflow. The effects of these recharge factors, however, are obscured to a much larger extent by the fluctuations caused by seepage (recharge) from surface irrigation.

Based on data from the Soil Conservation Service and the Conservation and Survey Division, (Handbook on the Preparation of Groundwater Management Plans), the following recharge rates have been compiled for the various regions in the NPNRD assuming average annual precipitation.

Region	Recharge from Precipitation
North Platte Valley Alluvium	3" to 5"/Year
Pumpkin Creek Valley Alluvium	3" to 5"/Year
Pumpkin Creek Valley Brule	0.5" to 0.8"/Year
Northern Tablelands	0.5" to 0.8"/Year
Sandhills Region	4" to 5"/Year
Cheyenne Southern Tablelands	0.2" to 0.8"/Year

2.2.1.2. Surficial Soil and Vadose Zone Description

Modern county soil surveys have been published for Scotts Bluff County (Reference 162). The county soil survey for Banner County is in press and for Sioux County the soil survey is in review. The soil survey for Garden County is in progress and almost complete. In addition, general soil maps of the Scottsbluff and Alliance areas, scale 1:250,000, were published by CSD-UNL in 1982. Each of these maps have a chart showing the soil association and the major soil series in each association. The chart also shows the following characteristics:

Composition of each major series (percent of each)
Topographic Position
Slope (Percent)
Parent Material
Depth
Drainage Class
Texture of Surface and Subsoil

Since the two maps are readily available to the NRD and others, the charts are not reproduced in this plan. A map (Figure 12-30) in this plan shows generalized soil types. Table 17 in the Morrill County Soil Survey report lists the physical and chemical properties of the soils. Table 16 of the Morrill County Soil Survey lists engineering index properties; Table 19 lists engineering index test data; Table 18 provides soil and water features including hydrologic group, frequency, duration and months soil subjected to flooding and an indication of depth of high water table. Table 13 of the Morrill County Soil Survey characterizes soils with respect to suitability for siting of sanitary facilities, and Table 15 lists soils and characterizes them with respect to water management.

The soil survey for Scotts Bluff County (Reference 162) provides information on soil infiltration rates, soil composition and structure, and soil chemistry. Table 4 in that report lists engineering tests data for representative soils at specific sites; Table 5 lists properties of soils including permeability, available water capacity, pH, and salinity; Table 6 lists information on engineering interpretation of soils for various uses including irrigation; and Table 8 lists particle-size distribution of some soil types and chemical analyses for them.

Soil surveys for Banner County (in press) and for Sioux County (in review) contain information relative to soil characteristics in detail similar to that provided in the Morrill County Survey. Preliminary information is available from the SCS, CSD and the NPNRD. Preliminary information for Garden County (soil survey almost completed) is also available.

The modern soil surveys in the NPNRD contain a wealth of information relative to the vulnerability to contamination of soils, the vadose zone and groundwater. This information, along with other information about the geology and hydrogeology, is of much value for planning groundwater protection strategies. However, due to the complexity of the geology, hydrogeology and soils, on-site investigation is still necessary to evaluate conditions with respect to siting of sanitary facilities, wells and land fills or to determine corrective measures in areas suspected to be contaminated.

Very little research has been done or analytical data developed on the hydrogeological characteristics of the vadose zone. Each of the soil surveys provides information on the physical characteristics of soils to depths of 60 inches. The logs of test holes drilled by CSD have been published in various reports. Test drilling in Morrill County and an interpretive report was done in cooperation with the NPNRD (References 70 and 70A). The characteristics of the consolidated and unconsolidated sediments are described in the logs of test holes. Coring to determine characteristics of the vadose has not been done specifically for that purpose. Perhaps some coring has been done incidental to investigations of contaminant sites or clean up, but that information is not available.

2.2.1.3. Depth to Groundwater

A depth to groundwater map (Figure 12-19) has been adapted from CSD work maps of the Scottsbluff and Alliance 1:250,000 scale maps showing contours of the water table (Figure 12-10) and from topography from the Scottsbluff and Alliance quadrangles, scale 1:250,000. Site specific information can be obtained by subtracting the elevation of the water table, as interpolated from the water table contour maps (Figures 12-10 and 12-11), from the ground elevation interpolated from the 7.5 minute quadrangle maps.

2.2.2. External Groundwater Recharge Sources

2.2.2.1. Natural Recharge Sources

2.2.2.1.1. Precipitation

Discussion of natural recharge from precipitation has been discussed previously (Section 2.2.1.1.1). Not noted in that discussion is the significant recharge to the valley lands in both the North Platte River and Pumpkin Creek Valleys (bottom lands, terraces, and the Brule Formation). Precipitation that runs off from the side slopes is a contributor to recharge in the valleys. Also, the precipitation that infiltrates to the water table on the uplands and side slopes reappears as stream flow and springs in the upper to middle reaches of a number of tributaries. The water in a number of tributaries that is not lost through evapotranspiration is "lost" as recharge to aquifers lower on the valley sides or to the alluvium. That recharge which is supplemental to that falling in the valley is substantial, but has not been quantified. A number of tributaries are losing streams in this regard, for example Lawrence Fork in Banner and Morrill Counties and Lost Creek above Oshkosh in Garden County.

2.2.2.1.2. Streams (Gaining/Losing)

The North Platte River, for the most part, is a gaining stream as previously discussed. Through releases from storage and due to return flows from irrigation either via the surface or the subsurface, the North Platte River became a gaining river in the early 1900's. Quantification of the gain is graphically displayed and discussed in Section 5.2.2.1. Studies to determine whether there are sections of the river that, under some conditions and for short periods, become a losing stream have not been done. Neither have seepage runs to determine stream losses or gains under low flow conditions been done. It is probable that at times stream losses may occur in some segments for short intervals of time.

Pumpkin Creek, particularly in its lower reaches, is a losing stream (see discussion in Section 2.1.2.4.1.2). The flow of Pumpkin Creek since about 1974 has been significantly reduced. That initial period of reduction in flow of Pumpkin Creek coincides with a period of extreme drought of about three years duration from 1974-1976 (Vernon Souders, 1993 Personal Communication). Although water levels in several observation wells recovered to pre-1974 conditions, the stream flow did not.

2.2.2.1.3. <u>Wetlands and Lakes</u>

Wetlands occur in the North Platte River valley. Wetlands and lakes are found in the Sandhills portions of Morrill and Garden Counties. Wetlands and lakes represent areas that are both recharge and discharge areas. The Sandhills area of the NPNRD is described as being semiarid in that evaporation exceeds precipitation by at least 20 to 25 inches. Although recharge occurs from precipitation, the net effect is that ET greatly exceeds recharge. The wetlands and lakes are thus considered to be areas of net discharge of water rather than recharge areas.

2.2.2.2. Artificial Recharge Sources

Recharge results from the storage of water in the NPNRD at Lake Alice and Lake Minatare. Quantification of the amount of recharge has not been calculated.

These two lakes are supplemental storage reservoirs for water diverted from the North Platte River into the Interstate Canal (Reference 99). The lakes supply water for surface irrigation, as well as recharge to the underlying aquifer, and provide excellent habitat for wildlife and opportunity for recreation.

The aquifer properties vary significantly in the North Platte Valley from place to place. The depth to groundwater, for instance, in general increases with distance from the North Platte River. Along the river bottoms the water table is less than 25 feet below land surface in most places, but beneath the bluffs and along the valley limits it is as much as 275 feet. The depth to the water table, however, does not increase uniformly from the river to the valley limits. Figures 12-10 and 12-11 indicate water table contours. The irregularity of the contour lines can be seen especially in the area north of the river. A flat and broad water table in the vicinity of Lake Alice and Lake Minatare is illustrated by the greater distance between water table contours.

Hydrographs developed in a study by Wenzel and others (Reference 79) indicate, in a general way, that the groundwater level in northeastern Scotts Bluff County, especially in the vicinity of Lake Minatare, probably has built up as much or more by seepage from the lakes and from canals that traverse the area than it has in most other parts of the region.

Each of the surface water projects provide incidental recharge as discussed in Section 2.1.2.4.1.1. Projects that have applied for incidental groundwater recharge are identified in Section 5.2.2.1.1.

3.0 Water Quality Inventory

The NPNRD Groundwater Management Plan, 1986, included a section on groundwater quality. Most of that portion of the plan is retained in this revised plan.

3.1. Current Water Quality Monitoring Program and Results.

Considerable new data and information on groundwater quality has been obtained since 1986. The NPNRD, as recommended and proposed in the 1986 plan, has made a major effort to obtain water quality information and to develop a database.

3.1.1. NPNRD Sampling Program

Since 1986 the NPNRD has sampled about 94 wells (most were domestic, but sampling included irrigation, public supply, and industrial wells) for a complete suite of inorganic parameters. Forty-two of these wells were sampled three times during the years from 1987 to 1992. Two wells were sampled twice and 42 wells were sampled once. Copies of the log forms used by the NPNRD to schedule wells used for sampling, and to record the water quality analysis, are included here as Figure 3.1.1-1, Sheets 1-8, and Figure 3.1.1-2, Sheets 1-3. Parameters obtained in the field include pH, temperature, conductivity, TDS, and NO_3N. These parameters, with the exception of temperature, are also analyzed in certified laboratories. Dates are recorded, as are the type of preservatives and containers used for shipment.

The NPNRD is in the process of incorporating all of their water quality data onto hard disks for storage, retrieval, and as an aid to evaluation of the data.

The NPNRD has also sampled an additional fifty-four wells to determine nitrate-nitrogen concentrations. The same two log forms are used for well schedules and recording analysis. Parameters obtained in the field were the same as collected for the complete analysis in most cases. A field determination of the concentration of nitrate-nitrogen was obtained for most wells. Samples also were submitted to the Nebraska State Laboratory for nitrate-nitrogen analysis. Thirty of the wells through 1992 were sampled once, some of the wells were resampled several times, in some cases as many as seven times since 1986 and 1987. Results of both complete and partial analyses are provided to the land owners.

Water quality sampling has been accomplished in part to obtain baseline information. Sampling has also been done at the request of landowners. As evidence, in particular, of nitrate-nitrogen concentrations approaching or above the 10 mg/l levels, sampling has been repeated and other wells sampled in the area.

3.1.2. NPNRD Water Quality Sampling Procedures

Samples for complete analysis have been submitted to A and L Laboratories in Omaha and to the Nebraska State Laboratory. A and L Laboratories are certified by the State Health Department and the laboratory uses EPA laboratory procedures. At times duplicate samples and blind samples have been submitted as a means of quality control.

3.1.2.1. Nitrate and Bacteria Sampling.

The procedures used to sample groundwater for nitrate and bacteria are listed as follows and will be adhered to by all employees of the North Platte NRD:

1. Each sample will be taken as close to the well head as possible, preferably before the water enters the pressure system.
2. Information on well construction, location, depth to water, use, pump, land use and any other pertinent information will be recorded on Sheet 1 of the Water Quality Schedule for each first time sampling. Information must be updated as conditions change when noted during further sampling.
3. Water will be run from the system for a minimum of 10 minutes before the sample is taken. If a flow-through chamber is used, measurements of pH, temperature, dissolved oxygen, and conductance must stabilize before the sample is taken.

4. Field measurements of water temperature, pH, specific conductance and total dissolved solids (TDS) will be made by collecting a sample from the water stream before sample bottles are filled. All instruments will be calibrated before use. The pH meter will be calibrated for each sample and the conductivity meter should be calibrated daily. All data will be recorded on sheet 2 of the Water Quality Schedule along with date, time of sampling, whether instruments have been calibrated, how samples are preserved and any additional comments or observations.
5. Samples will be collected and preserved in containers provided by the laboratories.
6. All samples will be shipped to the lab the same day as they are taken. A record of how the sample was shipped and when the laboratory received the sample, analyzed it, and reported the results will be recorded on sheet 3 of the Water Quality Schedule.
7. All information gathered under this program will be kept on file at the NRD office and copies of all analyses are sent to the landowners.

3.1.2.2. Baseline Water Quality Sampling

The following is a list of constituents analyzed for baseline water quality studies and the EPA Methodology for analysis:

Constituent	EPA Method Number*	Detection Level
Total Dissolved Solids	160.1	2.0 mg/l
Calcium	215.1	0.10 mg/l
Alkalinity	310.1	.0 mg/l
Sulfate	375.4	4.0 mg/l
Sodium	273.1	0.10 mg/l
Chloride	325.3	1.0 mg/l
Magnesium	242.1	1.0 mg/l
Nitrate	352.1	0.02 mg/l
Zinc	200.7	0.01 mg/l
Specific Conductance	120.1	1.0
pH	150.1	0.1

Total Organic Carbon	415.1	2.0 mg/l
Potassium	258.1	0.1 mg/l
Iron	200.7	0.05 mg/l
Manganese	200.7	0.01 mg/l
Phosphorous	365.2	0.1 mg/l
Ortho Phosphate	365.2	0.10 mg/l
Boron	200.7	0.02 mg/l
Silica	200.7	0.10 mg/l
Copper	200.7	0.01 mg/l
Fluoride	340.2	0.01 mg/l
Bicarbonate	403*	1.0 mg/l
Selenium	270.3	0.001 mg/l
Sodium Absorption Ratio	Calculation	

*Standard Methods, 16th Edition

Procedures used in sampling for baseline water quality in the district includes the following:

1. Each sample will be taken as close to the well head as possible, preferably before the water enters the pressure system.
2. Information on well construction, location, depth to water, use, pump, land use and any other pertinent information will be recorded on sheet 1 of the Water Quality Schedule for each first time sampling. Information will be updated as conditions change when noted during further sampling.
3. Water will be run from the system for a minimum of 10 minutes before the sample is taken. If a flow-through chamber is used, measurements of pH, temperature, dissolved oxygen, and conductance must stabilize before the sample is taken.
4. Field measurements of water temperature, pH, specific conductance and total dissolved solids will be made by collecting a sample from the water stream before sample bottles are filled. All instruments will be calibrated before use. The pH meter will be calibrated daily. All data will be recorded on sheet 2 of the Water Quality Schedule along with the date, time of sampling, whether instruments have been calibrated, how samples are preserved and any additional comments or observations.

5.

5. Samples are collected and preserved in containers provided by the laboratories.

6. All samples will be shipped the same day as they are taken. A record of how the sample was shipped, when the laboratory received, analyzed and reported on the sample will be recorded on sheet 3 of the Water Quality Schedule.

7. All information gathered under this program will be kept on file at the NRD office and copies of all analyses will be sent to the landowners.

3.1.2.3. Sampling Procedures Used for USGS Cooperative Studies

The following is a list of parameters analyzed for the reconnaissance study of groundwater quality in the NPNRD:

Constituent	Units of Measure	Detection Level
Well depth	Feet	1
Specific conductance, field	µS/cm	1.0
pH, field	Standard Units	.1
Water temperature, field	°C	.2
Oxygen, dissolved, field	mg/l	.1
Nitrates, dissolved	mg/l as N	.05
Hardness, total	mg/l as $CaCO_3$	1
Alkalinity	mg/l as $CaCO_3$	1
Dissolved solids	mg/l	1
Calcium, dissolved	mg/l as Ca	.10
Magnesium, dissolved	mg/l as Mg	.10
Sodium, dissolved	mg/l as Na	.10
Percent sodium, dissolved	percent as NA	1
Sodium-absorption ratio	--	--
Potassium, dissolved	mg/l as K	.10
Sulfate, dissolved	mg/l as SO_4	.10
Chloride, dissolved	mg/l as Cl	.10
Fluoride, dissolved	mg/l as F	.10
Silica, dissolved	mg/l as SiO_2	.10
Arsenic, dissolved	µg/l as As	1
Barium, dissolved	µg/l as Ba	2
Beryllium, dissolved	µg/l as Be	.5
Boron, dissolved	µg/l as B	10
Cadmium, dissolved	µg/l as Cd	1.0
Chromium, dissolved	µg/l as Cr	5

Cobalt, dissolved	µg/l as Co	3
Copper, dissolved	µg/l as Cu	10
Iron, dissolved	µg/l as Fe	3
Lead, dissolved	µg/l as Pb	<10
Lithium, dissolved	µg/l as Li	4
Manganese, dissolved	µg/l as Mn	<1.0
Molybdenum, dissolved	µg/l as Mo	10
Nickel, dissolved	µg/l as Ni	10
Selenium, dissolved	µg/l as Se	1
Silver, dissolved	µg/l as Ag	1.0
Strontium, dissolved	µg/l as Sr	1
vanadium, dissolved	µg/l as Va	6
Zinc, dissolved	µg/l as Zn	3
Gross alpha based on natural uranium curve	pCi/L as U	.4
Gross alpha based on thorium curve	PCi/L as Th	.4
Gross beta based on cesium-137 curve	pCi/L as ^{137}Cs	.4
Gross beta based on strontium-90 curve	pCi/L as ^{90}Sr	.4
Radium-226, dissolved	pCi/L as ^{226}Ra	.02
Radon-222, dissolved	PCi/L as ^{222}Rn	80
Total uranium	µg/l as U	.10
Uranium ratio, uranium-234/238	$^{234}U/^{238}U$	--

3.1.2.3.1. Methodology

One hundred twenty wells were sampled from June through July of 1991 (Reference 152). Onsite observations include observation of well integrity, determination of land-surface altitudes at each sample site, and observation of prevalent land use. The altitudes (land-surface datum) for all well sites were determined from U.S. Geological Survey 7-1/2 minute topographic maps (scale 1:24,000) with 5- or 10-foot contour intervals. Prevalent land use and apparent potential point sources within a 1-mile radius of the sample location were noted on the field data sheets to aid in the interpretation of anomalous water chemistry.

Each well was sampled as close to the well head as possible. Using a flow-through chamber, specific conductance, the pH, water temperature, and dissolved oxygen (when possible) were measured onsite. A sample that was collected after measurements, made every 5 minutes, indicated that these water-quality properties had stabilized (typically after 15 and before 25 minutes had elapsed). The properties were considered stable upon the basis of the following tolerances:

Specific conductance: 5 percent;

pH: 0.1 standard units; and

water temperature: 0.2 °C.

These procedures were assumed to yield water samples representative of the aquifer surrounding the well screen.

A water sample from each of the 120 wells was filtered immediately, preserved, and kept chilled at 4°C for dissolved-nitrate analysis. At each site, an additional sample was collected in a chilled-amber glass bottle for triazine-herbicide analysis. In addition, samples from the 44 selected wells were analyzed for concentrations of major cations and anions, trace metals, radionuclides, pesticide, and aldicarb. Finally, 30 well samples were selected at random for additional analysis for the herbicide 2, 4-D. All samples were filtered and preserved onsite as required (Pritt and Jones, 1989).

3.1.2.3.2. Laboratory Procedures

Analyses for nitrite plus nitrate, major cations and anions, trace elements, gross alpha and beta radioactivity, radon (Ra^{222})(syringe method), and radium (Ra) were done in accordance with the standard methods used at the U.S. Geological Survey National Water-Quality Laboratory (NWQL) in Arvada, Colorado (Fishman, and Friedman, 1989). The concentrations of nitrite (NO_2) plus nitrate (NO_3), considered to be mostly NO_3 under freshwater conditions and generally reported as nitrogen (N), will be referred to as N in the remainder of this report. Analyses for uranium (U) concentrations and uranium-234 divided by uranium-238 ($^{234}U/^{238}U$) isotopic ratios were done at the U.S. Geological Survey laboratory in Reston, Virginia, using an isotope-dilution method (Thatcher, Janzer, and Edwards, 1977).

Concentrations of the insecticides and herbicides were determined using a two-tiered approach to decrease laboratory cost. An enzyme-assay test kit was used in the laboratory to detect the following compounds: ametryn, atrazine, cyanazine, de-ethylated atrazine, Diazinon, di-dealkylated atrazine, 6-hydroxy atrazine, prometon, prometryn, propazine, simazine, simetryn, terbuthylazine, and trietzaine. All samples were tested onsite for total triazine content using an enzyme-assay test quantified qualitatively with a differential photometer. If a sample contained more than 0.10 µg/l (microgram per liter) of triazine compounds according to the enzyme-assay test, it was sent to the U.S. Geological Survey National Water-Quality Laboratory (NWQL) for quantitative analysis of triazine and other nitrogen-containing herbicides using solid-phase extraction and GC/MS (gas chromatography/mass spectrometry). In addition, five sample blanks were sent to the U.S. Geological Survey National Water-Quality Laboratory (NWQL) as a quality-assurance check. Forty-four samples were analyzed for triazine and other nitrogen-containing herbicides at the NWQL. These analyses included alachlor, ametryn, atrazine, cyanazine, deisopropylatrazine, desethylatrzine, metolachlor, metribuzin, prometon, prometryn, propazine, and simazine.

Similarly, 46 samples, selected in accordance with the statistical sampling scheme including some samples where aldicarb was known to be used on beets at the sample site, were tested with an enzyme-assay kit for the presence of aldicarb, aldicarb sulfone, and aldicarb sulfoxide. If a sample contained more than 1.0 µg/l of carbamate insecticides according to the enzyme-assay test, the sample was analyzed for carbamate insecticides at the NWQL using liquid chromatography. Again, seven sample blanks were sent for quantitative analysis to the NWQL. Thirteen Samples were analyzed at the NWQL for carbamate insecticides, which include aldicarb, aldicarb sulfoxide, aldicarb sulfone, carbaryl, carbofuran, 3-hydroxycarbifuran, methiocarb, methomyl, naphthol, oxamyl, propham, and propoxur.

3.1.2.4. Quality Assurance and Quality Control (QA - QC)

The NPNRD sampling program includes QA-QC as follows.

3.1.2.4.1. Nitrate and Bacteria Analysis

QA-QC consists of taking duplicate samples and distilled water blanks for testing laboratory accuracy. Duplicates and blanks are sent to the lab on a random basis.

Labs are selected on their ability to perform analysis using EPA approved methodology. Labs must be certified by an appropriate entity of government.

3.1.2.4.2. Baseline Water Quality Sample Analysis

QA-QC consists of taking duplicate samples on a random basis and having them analyzed at the same laboratory.

Labs are selected on their ability to perform analysis using EPA approved methodology. Labs must be certified by an appropriate entity of government.

A list of the EPA methodology for parameters analysis has already been addressed earlier in the text.

3.1.2.4.3. USGS Cooperative Studies Lab QA-QC

The studies conducted cooperatively with NRD and USGS use the following methodology:

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

3.1.3. Description of Database and Sampling Results

The North Platte NRD began monitoring domestic wells in the Oshkosh area in 1987. Results of monitoring west of Oshkosh in 1988 and 1989 indicated that samples from a number of wells in that area have nitrate-nitrogen concentrations exceeding 10 ppm. The NRD entered into a contract with the Conservation and Survey Division, UNL, in 1989 to undertake an investigation to determine the source of nitrate occurrence west of Oshkosh. The area studied by Mary Exner Spalding was generally along the highway west-northwest of Oshkosh for about five miles. The study conducted in 1989 included the installation of five monitoring wells (three of which were multi-level samplers), observation of water levels, chemical analyses and evaluation, and examination of nitrogen isotopes. The study was published in February 1990 (Reference 118).

Spalding noted that two multi-level sampling wells in the SE ¼ Sec. 19-17N-44W (about 4 miles west and one mile north of Oshkosh) were "characterized by very high nitrate-nitrogen concentrations in the upper thirty feet of the aquifer and a sharp decrease in concentration between 30 and 40 feet." She concluded that, "The higher concentrations at the top of the aquifer result from loading of the groundwater as it flows beneath corn fields." She also noted that, "It has been shown that the head of a gravity-irrigated field receives considerably more irrigation water than the lower end of the field. Consequently, there is more leaching of nitrate at the upper end of the field." Concentrations of more than 25 ppm nitrate-nitrogen was noted in one of the two wells from 40 to 60 feet. Isotopic ratios measured in 12 samples suggested that the source of nitrate contamination was from commercial fertilizer. Based upon water levels from a limited area, and from water level depths measured on July 27 and 28, 1989, she assumed that groundwater flows in a north-south direction, and that recharge was derived from recharge in the Sandhills. Both of these assumptions are only partly correct in that most of the recharge is localized (or is from upland runoff), and although there is a component of north to northeast flow of groundwater from the north valley side slopes, groundwater flow in the valley generally is parallel to the river (Figure 12-23).

A map (Figure 12-23) depicting an area with a six mile radius centered on Oshkosh shows the location of wells sampled for nitrate-nitrogen, and the concentrations of nitrate-nitrogen obtained since 1988. Most of the values are for 1991 or 1992 and are from samples collected by the NRD. Values collected from the monitoring wells installed by Spalding and a few from irrigation wells sampled by the USGS are included. Some variation in values can be expected depending upon the year, time of year, type of well, depth of well, type of construction, and potential sources of point or non-point contamination. Even with the many variables taken into consideration, two mappable areas with concentrations of more than 10 ppm nitrate-nitrogen are displayed, one west of Oshkosh and the other to the east. For the most part, the patterns suggest that contamination within the boundaries is primarily from non-point sources, probably resulting from excess application of water and excess or poor distribution of fertilizer.

The water table contours and direction of groundwater flow in spring 1992, suggest a strong component of flow in the valley parallel to the river (Figure 12-23). The direction of flow probably is representative of groundwater movement for most of the time. Locally, groundwater withdrawal may alter the direction of flow, and there may be some interchange of groundwater and stream flow near the river. Locally, about two miles southeast of Oshkosh, water from the river appears to be moving to Lost Creek. Lost Creek, which is a perennial stream for several miles north of Oshkosh, loses its flow about one mile north of Oshkosh, recharges the valley alluvium, and may tend to reduce nitrate concentration in the village area. The movement of groundwater from the contaminated "cells" appears to be away from Oshkosh, however, long term pumping, particularly after a succession of dry years, may permit movement of contamination toward the village wells. According to the State Department of Health (DOH) (oral communication), water sampled from three wells in Oshkosh in November 1974 had an average nitrate-nitrogen concentration of 0.4 ppm. Water sampled from the distribution system in Oshkosh more recently showed the following nitrate-nitrogen concentrations: December 1988 - 5.4 ppm; October 1989 -3.1 ppm; November 1990 - 5.0 ppm; and November 1992 - 4.0 ppm.

Much of the irrigable land in the Oshkosh area derives supplemental water only from wells. The irrigation ditches have been abandoned north and west of Oshkosh. The North River Canal along the north side of the river valley was abandoned in 1901, the Spohn Canal was abandoned in 1960, the Lyons Canal in 1959, and the Oshkosh Canal in 1969. The Midland-Overland Irrigation District and Canal are still in operation southeast of Oshkosh. Perhaps it is coincidental that the only area in which there appears to be mappable concentrations of nitrate-nitrogen greater than 10 ppm is also one of the few irrigated areas in the North Platte River Valley not in some way directly influenced by surface water use (see Figure 12-35). Circumstantial evidence suggests that surface water, as presently used elsewhere in the valley, either dilutes or flushes nitrates from the groundwater system. The NPNRD is continuing to monitor wells in the area and investigate nitrate-nitrogen occurrence. A detailed investigation in cooperation with the U.S. Geological Survey (USGS) in the Oshkosh to Lewellen area was begun in April 1993.

As further evidence of the commitment of the NPNRD to emphasize water quality data collection and assessment, the NRD entered into an agreement with the USGS in 1990. The cooperative effort of the USGS, NPNRD and CSD was focused on sampling for nitrate and nitrite as nitrogen, agricultural organic pesticides, and radionuclide concentrations and other activities. The purpose of the study was to aid the NRD in identifying levels and sources of groundwater contamination and to propose and develop methods to stabilize, reduce, and to prevent to the extent possible additional spread, occurrences, and increases in groundwater contamination (Reference 152).

The USGS Report summarizes results of investigations done cooperatively with the NPNRD and CSD. Samples from 120 wells selected to represent unconfined geologic units of Quaternary, Ogallala, Arikaree and Brule water bearing units and wells representing confined Chadron and Cretaceous units were collected during June and July 1991. Analyses of water samples from all wells included determination of dissolved nitrate and nitrite as nitrogen, triazines and acetanalides. "A subset of 46 samples were analyzed for total carbamate insecticides, and 30 water samples were quantitatively analyzed for 2, 4-D and related chlorophenoxy acid compounds. Water quality analyses of a subset of 44 water samples included dissolved major cations and anions, major metals, trace elements, and radionuclides" (abstract, Reference 152).

Nitrate and nitrite as nitrogen was found to be equal to or greater than 6.0 mg/l in one-fourth of the 120 wells. Water samples from six wells completed in the Quaternary deposits and the Brule Formation fractures had more than 10 mg/l nitrate and nitrite as nitrogen. Water sampled from the confined units had concentrations generally less than the detection level, explained in part by the presence of a reducing environment. Samples from several wells completed in the Quaternary (alluvium) and the Brule had detectable concentrations of alachor, atrazine, desethlatrazine and prometon.

The report describes the laboratory procedures used and the quality control and quality assurance in considerable detail. A two-tier approach to decrease laboratory costs in determining concentrations of insecticides and herbicides was used. An enzyme-assay kit was used to detect the presence and to estimate quantitatively the content of total triazine and to detect the presence of aldicarb, aldicarb sulfone, and aldicarb sulfoxide. If a water sample contained more than 0.10 micrograms per liter of triazine compounds according to the enzyme-assay test, it was sent to the National Water Quality Laboratory (NWQL) for quantitative analyses. Water samples containing more than 1.0 micrograms per liter of carbamate insecticides were also sent to NWQL for analyses using liquid chromatography. Thirty-nine water samples and five blanks sent to NWQL for analyses of triazine and other nitrogen containing herbicides were analyzed for alachor, ametryn, atrazine, cyanizine, deisopropylatrazine, desetylatrazine, metrolachlor, metribuzin, prometon, prometryn, propazine, and simazine. Thirteen water samples were analyzed by NWQL for carbamate insecticides including aldicarb, aldicarb sulfoxide, aldicarb sulfone, carbaryl, carboform, 3-hydroxycarbifurm, methiocarb, metomyl, 1-naphthol, oxamyl, propham, and propoxur. Water samples from 30 wells were analyzed for 2, 4-D and related clorophenoxy acid compounds. These compounds were not detected in these samples.

The USGS report summarizes the results of enzyme-assay and NWQL analyses, "The minimum and median concentrations of all herbicides and insecticides are all below detection levels", and "All detections were less than the U.S. Environmental Protection Agency proposed Maximum Contaminant Levels (MCL's) of 2.0 µg/l for alachlor and 3.0 µg/l for atrazine (U.S. Environmental Protection Agency, 1988)." Groundwater from seven wells found to be contaminated with atrazine were collected from Quaternary (alluvial) aquifers in the North Platte River Valley, and the locations of the wells corresponded to irrigated areas, specifically near Oshkosh in Garden County and between Bridgeport and Scottsbluff in Banner and Scotts Bluff Counties. One well completed in the Ogallala Group and located in the upland showed contamination with atrazine. The authors of the USGS report suggest that, "Additional information on the distribution of land use and pesticide use is needed to adequately establish relations among these water quality variables and contamination originating from agricultural practices."

A table listing the results of analyses for herbicides and pesticides is included in the report as is a figure showing sampled well locations and the wells having groundwater containing detectable concentrations of selected herbicides.

About 100 domestic wells were sampled in the NPNRD in the period 1986-89 as a part of a statewide assessment by the State Health Department Center for Disease Control (CDC). The results were summarized by Spalding, 1991 (Reference 172). Samples were analyzed for thirteen types of pesticides commonly used to control weeds and insects. With the exception of six wells from which atrazine was detected, no other pesticide was detected. Atrazine concentrations were low. Five of the wells had concentrations ranging from 0.20 to 0.24 ppb, and one had 0.82 ppb. Samples were also analyzed for nitrate-nitrogen and the results from those tests are discussed later.

3.1.3.1. Radionuclides Sampling & Results

As indicated previously, a subset of 44 water samples were analyzed for radionuclides (Reference 152). Analyses from wells completed in the Quaternary and Brule fractured water-bearing units "suggested common exceedence of adjusted gross alpha units". The larger gross beta activities in these units compared to other units suggest to the authors of the report that, "The water is relatively young as it has been affected by radioactive fallout due to atmospheric testing of nuclear weapons".

Thirty-nine of the 44 wells completed in all water bearing units, except the Arikaree, contained water that exceeded the proposed MCL of 300 picocuries per liter of radon. "Water from the Brule, Chadron, and undifferentiated cretaceous water-bearing units had significantly large radon activities." However, "Median total uranium concentrations and gross alpha were largest in the Quaternary deposits and the median uranium ratio 234/238 was largest in water from the undifferentiated cretaceous water bearing units." A statistical summary of water quality analyses for gross alpha based on strontium 90 curve, dissolved radium-226, and dissolved radium-223 is presented in tables in the USGS report (Reference 152). The distributions of radionuclide by water bearing units and of uranium by county is illustrated in a figure.

The adjusted gross alpha MCL was exceeded in nineteen or more wells, mainly in the Quaternary deposits; the proposed MCL for radon-222 was exceeded in 39 of the 44 selected wells (the range was from 300 to 1500 pCi/L); and the uranium primary contaminant level of 20 µg/l U was exceeded in nine wells completed in the alluvial and Ogallala deposits (range was from 20.7 to 72.2).

Radionuclide concentrations in groundwater and variations in their distribution are related to natural occurrences of radionuclides in sediment and to contamination by human activities. Fertilizer can be one source, as reported in the literature. Over-exposure to radiation is considered to be a cause of cancer in humans, and radon and radium are considered to be the main nuclides emitting alpha radiation from water. The extent of the occurrence of radionuclides in the NPNRD, the hazard to humans, and the factors in combination which determine their occurrence and behavior does not appear to be clearly or completely understood at this time. Research over the long term will be needed to provide the answers.

Most of the wells from which water samples were analyzed for radionuclides were irrigation wells in the USGS study. The Nebraska Department of Health (DOH) sampled and analyzed water for radionuclides from public water supply systems in Scotts Bluff, Morrill, and Garden Counties in the period 1987-1989. In addition to all 12 city and village systems, six other public water supply systems were sampled for gross alpha, radium-226, and most for uranium. All wells were resampled for gross alpha and a few for radium-226. A printout provided by DOH listing the results of the analyses has been made available.

The current and proposed MCL of 15 pCi/L for adjusted gross alpha was exceeded in the water supply of 12 of the 18 sampled systems. The three highest values were 35, 37.6, and 38.4 pCi/L. Probably all of the wells were completed in the alluvial deposits. The values obtained for radium-226 were well below the current MCL of 5 pCi/L (when combined with Ra-228). The concentration of uranium in water from 11 water systems ranged from 17.1 to 66.8 µg/l, and 10 of the of the systems had values near or greater than the proposed (1991) MCL of 20 µg/l (equivalent to about 30 pCi/L).

The Nebraska DOH sampled public water supply systems statewide for radon analyses in 1991 (Reference 177). A total of 106 samples were obtained. Most samples were from the system although at sites where radon concentrations were high individual wells were also sampled after the initial sampling of 56 systems. The public water systems for Oshkosh, Broadwater and Scottsbluff in the NPNRD were sampled in the initial survey and the radon in pCi/L for each of the cities was 296, 842, and 466, respectively.

DOH estimated that at least 50 percent of the public water systems in Nebraska would exceed the proposed 300 pCi/L MCL for radon (References 177 and 178). They have recommended to the EPA that the proposed MCL for radon be raised from 300 pCi/L to at least 2,000 pCi/L and that the 2,000 pCi/L minimum level is consistent with the radon MCL recommended by the National Conference of Radiation Control Program Directors. DOH estimated the cost of a treatment plant with a capacity of 100,000 gallons/day to be in the range of $250,000 to $300,000 and if the source water has iron above 0.3 mg/l and/or manganese above 0.05 mg/l, an additional cost of $65,000 to $100,000 would be required. Annual operating cost might range from $18,000 to $36,000.

Based on the USGS cooperative study in which 39 of 44 wells sampled and analyzed for radon showed concentrations greater than 300 pCi/L (median activity of 500 pCi/L and a range from about 140 pCi/L to 1,500 pCi/L), most public and private water supplies in the NPNRD would not meet the proposed MCL for radon.

The final rules establishing radon and other radionuclides MLCs were to have been issued in April 1993 by EPA. That deadline was not met. The rules were intended to become effective October 1994 and the first round of monitoring was to have been completed by January 1999. At that time, suppliers would have to report violations. When the rules will be issued and at what levels MCLs will be established is not known.

The occurrence and concentration of radionuclides in the North Platte River Valley and alluvium in the NPNRD appear to be similar to those reported by Spalding and Loope, 1978-1983 (Reference 175) for the Central Platte region (Central Platte NRD). Uranium concentrations reported for that area (all north of the river) ranged from less than 1 ppb to more than 100 ppb (about 1 mg/l to 100 mg/l). Most of the higher concentrations were along the bottomland and in the upper portion of the aquifer, however, in parts of the area, the highest concentrations were toward the base of the Pleistocene sands and gravels (wells are constructed in this area in recent alluvium, pleistocene sands and gravels, and the Ogallala Group). The authors (Reference 175) reported that the average of uranium concentration of 10 samples collected from the Platte River near Shelton was 24 ppb. The areas irrigated with surface water from the Platte River since the late 1890's generally had low (less than 10 ppb) concentrations of uranium in groundwater. The low levels of uranium in the surface irrigated portion of the NRD would suggest that the irrigation of soils and land on the higher terraces from the Platte River source has not contributed measurably to uranium contamination. The authors of the report accompanying the map suggest the possibility of recharge from the Platte as contributing to uranium in groundwater. The high concentration of uranium on the bottomlands is attributed primarily to the practice of irrigating soils with high salt content. Leachate from the soils, either through recharge from precipitation or return flows from water applied on the land, appear to contribute to the high levels of uranium. Salts have accumulated in the soils (the process may be continuing) through evaporation in shallow water table areas. Although phosphate fertilizer can be a source of uranium (Reference 175), Spalding (oral communication, 1993) suggests that the use of phosphate fertilizer in this area is not considered to be a significant factor in accounting for the high levels of uranium concentration. Radium-226 concentrations in groundwater in the Central Platte region were found to be low, ranging from 0.02 to 1.1 pCi/L, and averaging 0.21 pCi/L (Reference 175). Similar or lower concentrations of radium-226 were found in the NPNRD by DOH and the U.S. Geological Survey (Reference 152).

Contamination of radionuclides in groundwater in the NPNRD at concentrations greater than MCL's either currently established, proposed July 16, 1981, or that may be proposed by the EPA, has been clearly established. Adjusted gross alpha, radon-222, and uranium concentrations in many wells sampled and analyzed to date are near or greater than current or proposed federal MCL's. Current understanding of the occurrence and concentration of radionuclides in surface or groundwater in the NPNRD strongly suggests they are natural. Research may provide more definitive information about the causes for the apparent large range in concentrations of some of the radionuclides. Although radionuclide contamination could be considered a kind of non-point contamination problem, the responsibility for addressing it for public water supplies rests primarily with the Nebraska Department of Health, not the NPNRD. The role of the NRD is in the sharing of information, cooperation, and coordination with DOH. The cost of analyses for radionuclides for individual non-public wells may be prohibitive for either the individual or the NRD. A long term program of the NRD will be that of education and advisement based upon results of the current state of knowledge.

3.1.3.2. Nitrates in Public Drinking Water Testing and Results

There are about 72 public water supply systems in the NPNRD according to records provided by DOH and most of them are in Scotts Bluff County. A summary of available information on the results of sampling and analyses for nitrates was provided to the NRD by the Natural Resources Commission Data Bank. The results of analyses of the 12 villages and cities and 15 of the other large water supply systems are presented in Table 3.1.3.2-1. The data is for the period 1987-1989 and represents sampling from a system of more than one well. The number of times sampled range from one to four, although most were sampled three times. None of the village and city water supplies had concentrations of nitrates above 10 mg/l, and the mean value for only one was about 7 mg/l, most were below 3 mg/l.

Table 3.1.3.2-1

Nitrates (Mean Value in mg/l)

	0-3	**3-5**	**5 - 7.5**	**7.5 - 10**	**Above 10**
Number of Systems	14	6	5	1	1

A second summary of nitrate concentrations from an additional 13 water supply systems sampled mostly from 1989 to 1992 show higher levels of nitrates. These systems include mobile home parks, school districts, and other small suppliers. Results are listed in Table 3.1.3.2-2.

Table 3.1.3.2-2

Nitrates (Mean Value in mg/l)

	0-3	**3-5**	**5 - 7.5**	**7.5 - 10**	**Above 10**
Number of					

Systems	1	1	2	5	4

No information has been provided on well location, depth of well, depth to water, type of construction, etc. Information prior to about 1987 concerning nitrate concentrations is also not readily available. Trends in levels of concentrations of nitrates, thus, cannot be determined. DOH does, of course, have primary regulatory responsibility for public water systems. However, the NPNRD has a significant interest not only in the water quality of the supply, but also in protecting the supply.

Through formal or informal cooperative agreements with DOH, the NPNRD could help provide well scheduling information including well registration, determine whether source of contamination is point or nonpoint, share in interchange, storage and retrieval of data, advise with respect to remedial action or alternative sources and wellhead protection.

3.1.3.3. Summary of Water Quality in Principal Aquifers

Analyses of major element chemistry of the 120 wells sampled and analyzed in the USGS Study are presented in that report (Reference 152) in tables, illustrated by figures and discussed by water bearing units. Water from the Quaternary, Ogallala, Arikaree, and Brule units was described as being generally a calcium-bicarbonate type with moderate hardness. That from the Chadron and undifferentiated Cretaceous units was generally considered to be a sodium-bicarbonate type with soft, mineralized water.

In general, the water quality in Quaternary deposits was considered to be more variable than in the other water bearing units. The variability was suggested as possibly being due to effects of local recharge from irrigation canals and the North Platte River, and to point and non-point sources of contamination. Use of potassium phosphate in agricultural areas may also be responsible for large potassium concentrations in the water from Quaternary (alluvial) deposits.

Natural sources of potassium from minerals abundant in these deposits contribute to potassium concentrations, as well.

The Chadron and undifferentiated Cretaceous water bearing units (sodium-bicarbonate type) have water with large alkalinity and sodium absorption ratios and large median sodium and fluoride concentrations. Chloride concentrations were highest in the Chadron. Silica concentrations were significantly lower in the Chadron and Cretaceous units. Sulfate and nitrate concentrations were low, as was dissolved oxygen. Water from these confined units, having large specific conductance and sodium-absorption ratio values, is suggested as being unsuitable for irrigation due to adverse effects on crops. Due to high concentrations of chloride and fluoride, water from these units may not be suited for domestic use.

Smith and Souders (Reference 93) also noted that two of the three wells tapping the Lance and one of the four tapping the Chadron had fluoride concentrations higher than the recommended maximum for drinking water. In two of the wells developed in the transitional zone of the Pierre Shale, boron concentrations were about 4 mg/l.

Water samples were analyzed for major metals and trace elements in the 120 wells sampled in the USGS cooperative study. Results of the analyses are listed in a table in the report. Boxplots showing the distribution of arsenic, barium, boron, iron, lithium, selenium, strontium, vanadium, and zinc are presented in Figure 5 of the report (Reference 152). Trace elements were not detected in many of the water samples. Samples were also analyzed for cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, and silver and are listed in a table. Concentrations were below MCL's except for two wells exceeding the manganese Secondary MCL (SMCL) completed in the Quaternary. The Primary MCL (PMCL) for arsenic was exceeded in one well in the Chadron and the proposed PMCL for beryllium was exceeded in two wells completed in the Chadron.

As discussed earlier in this section, the NPNRD has been concerned about contamination of groundwater by nitrogen. The results of the several efforts to assess and evaluate the occurrence of the concentrations of nitrate-nitrogen in the NPNRD have been summarized and displayed in Figure 12-22, showing the location of sampling sites and the concentration of nitrogen. Identification of source of the data is not shown for the 399 data points. The data is available on disks, in reports, or in files. The period during which sampling was done and analyses made is from 1986-92. The principal source for the data is the results of testing by the NPNRD, the cooperative USGS Study and the Nebraska Department of Health CDC Study. Values of nitrates less than 5.0, between 5.0 and 7.5, between 7.5 and 10, and more than 10 mg/l are depicted on the map. The only area in which it appears possible to map concentrations of more than 10 mg/l nitrate-nitrogen is in the Oshkosh area discussed earlier and presented as Figure 12-23. There are some areas along Pumpkin Creek in Banner County and some areas in Scotts Bluff County (i.e., near Scottsbluff, the Melba-Minatare area, and north-northwest of Morrill) where a number of wells have concentrations between 5 to 7.5 or 5 to 10 mg/l. Elsewhere there appears to be a scattering of values. Some wells were sampled that had nitrogen concentrations below 1 mg/l. Water samples from other wells had nitrogen concentration values as great as 30 to 40 mg/l.

If it is assumed that the natural levels of occurrence of nitrate-nitrogen is low (0 to 2 mg/l), any concentrations over that level can be assumed to have been affected by human activity. Almost surely nitrate-nitrogen contamination at levels approaching or greater than 10 mg/l has been a problem since settlement occurred in the area. Animal and human wastes associated with improper well siting, construction, and depths account for contamination of groundwater by nitrates. Some, if not many, of the present day high levels of nitrates in the NRD can be accounted for as being point source problems. Some well owners have replaced wells having water with high levels of nitrates by either choosing another site, properly constructing wells, and/or drilling deeper wells (oral communication, NRD staff, 1992). Spalding, 1990 (Reference 118), found evidence of a tendency for higher concentration of nitrates in the upper portion of the aquifer in the Oshkosh area.

The above discussion has to do with "point" sources of contamination and it is the intent of the NPNRD to continue to address point sources of contamination of nitrate-nitrogen through their service role of sampling, alerting water users and advising of alternative or corrective measures. That role, which is shared with the County-City Health Department in Scotts Bluff County and The Nebraska Cooperative Extension, includes a strong emphasis on education. The latter agency has available a publication titled "Perspective on Nitrates", Reference 165.

Contamination from either point or non-point nitrate sources appears to be the greatest in shallow wells in the alluvial deposits and in the jointed or fractured Brule Formation. Contamination and the potential for contamination appears to be greatest in areas of permeable soils and shallow depths to groundwater. There also appears to be some correlation between the use of surface water for irrigation and nitrate contamination. Although relatively high concentrations of nitrates occur in the surface irrigated areas, somewhat higher concentrations occur in the Pumpkin Creek Valley and in the Oshkosh areas.

One hundred and three of the 120 wells sampled in 1991 in the USGS cooperative study were irrigation wells. Almost seven percent of these wells were found to have concentrations of 10 mg/l or more of nitrates. One-fourth of the wells had concentrations of 6.0 mg/l or more. All of the 121 wells sampled in the State Health Department CDC survey were domestic wells. Fourteen percent of these wells had nitrate concentrations above 10 mg/l. Of the 178 wells sampled by the NPNRD, most were domestic wells, 18 were irrigation. Only one of the irrigation wells had nitrate concentrations of more than 10 mg/l. Twenty-eight of the other 160 wells sampled (17.5%) had nitrate concentrations greater than 10 mg/l. The higher apparent percent of domestic wells sampled over irrigation wells is perhaps to be expected as suggested previously due to well siting, depth of well, construction, and old age. The somewhat greater percent of domestic wells contaminated with nitrates in the NRD sampling program is biased in part because sampling was done to investigate suspect areas. In general, sampling of irrigation wells, where available, would appear to provide the most reliable information with respect to non-point contamination of nitrates.

Identification of whether the source of contamination is point or non-point is somewhat difficult as is the interpretation of movement or "spread" of contamination over time. A review of results of sampling to date show that in a number of areas in the NRD significant variability of nitrate levels occur quite commonly in wells closely spaced. The explanation is not clear. Only limited data is available and is inconclusive with respect to seasonal variability of nitrate levels. The cost of installing monitoring wells primarily for determination of water quality and changing trends over time is considered to be prohibitive because of the hydrogeologic complexity in the NPNRD. The only dedicated, water quality monitoring wells known to have been installed were those constructed for the Oshkosh area (Reference 118). Those wells will be monitored periodically and during investigations planned by the NPNRD in cooperative studies.

At the present time installation of monitoring wells for either research purposes or to determine trends is not planned. The fact that nitrate contamination has increased in areas of the NPNRD appears reasonably well established. The length of record, however, is too short to determine trends or even to determine when the present levels of contamination were reached. The NPNRD plans to address the existing and potential problems of non-point source nitrate contamination in a number of ways:

5.

1. Repeat sampling of selected irrigation wells and a few domestic wells at periodic intervals of three to five years to determine extent of problems and trends in levels of contamination.

2. Cooperate and share information with the State Department of Health with respect to monitoring of public water supplies. Consider public water supply wells to be monitoring wells.

3. Emphasize prevention of nitrate contamination through education and voluntary adoption of best management practices, including the appropriate application of water from surface and groundwater supplies for irrigation.

4. Map and develop boundaries of areas where it is determined that nitrate levels are in the range of 7.5 mg/l NO_3N. Develop rules and regulations based on best management practices to prevent further contamination and to reduce the levels of existing contamination.

Transport models to determine the movement and behavior of nitrates or other chemical constituents in any of the aquifer units is not being planned at this time. The database is inadequate with respect to either knowledge of areal distribution of chemicals affecting water quality or the hydrogeology. The cost of obtaining more detailed water quality information or more detailed and accurate descriptions of aquifer properties and their variability is believed to be prohibitive based on the current NPNRD budget.

3.1.4. <u>Suitability Characteristics of Groundwater in the NPNRD</u>

In general, the water quality for irrigation and livestock use, except as discussed previously in Section 3.1.3, is good. Water from the Chadron and older formations is not considered to be suited for irrigation or well suited for domestic use. Otherwise, and with some exceptions, groundwater is generally suitable for domestic use.

Exceptions include areas contaminated by gross alpha, radon-222, uranium and nitrates. Total dissolved solids in some wells in the alluvium and in the Chadron and older formations exceeded secondary maximum contaminant levels.

3.2. Existing Water Quality Summary

Groundwater quality is extremely important in the North Platte NRD as well as the entire State of Nebraska. The quality of groundwater can determine what uses can be made of the water and in effect can limit the quantity of groundwater available for use.

Water drains downward from the soil under the influence of gravity dissolving soluble minerals in its path. Natural material is rarely uniform and more recharge water moves through certain parts of this zone than other parts. Presence of tight impermeable layers may divert the infiltrating water from its downward course. Water may then be isolated above the main water table and it will possibly move laterally or become a perched aquifer.

The water table is the level below which all the earth materials are saturated. Water reaching this saturated zone moves under the influence of hydraulic pressure gradients, as discussed earlier, toward discharge areas such as springs, streams, lakes, wetlands, or wells.

Rocks and sediments along these groundwater flow paths contribute contaminants to the water. The type of earth materials and amount of time the water is in contact with them greatly influence the quality of the groundwater.

Water which is high in hardness may require treatment to be suitable for domestic and other uses. The major constituents of dissolved solids in Nebraska's groundwater are calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride and silica. Other chemical characteristics include alkalinity (bicarbonate), fluoride, boron, iron, selenium, phosphorous and nitrate. Many of these characteristic chemicals are not considered hazardous and limits of concentration in drinking water have not been established by the Environmental Protection Agency. Exceptions to this are nitrate, selenium and fluoride.

3.2.1. Water Quality in the Principal Aquifers

Most of the water quality data collected pertains to the principal aquifer of the area. A brief explanation of the major chemical constituents in the NPNRD follows. Refer to Figures 12-24 through 12-28 and Table 3.2.1-1 for concentration distributions for some of the major constituents in the NPNRD.

3.2.1.1. Dissolved Solids concentrations range from less than 200 to 1,000 mg/l within the regions of the NPNRD (Figure 12-24). Concentrations below 500 mg/l are generally considered favorable for aesthetic considerations and most crop tolerance. If leaching or drainage is adequate, concentrations up to 1,500 mg/l are not likely to be harmful. Some of the higher concentrations of dissolved solids are due to irrigation return flow in the valley alluvium both in Wyoming and Nebraska.

3.2.1.2. Hardness of groundwater reported as calcium carbonate ($CaCO_3$) ranges from 60 to 360 mg/l (Figure 12-25). Hardness concentrations greater than 180 mg/l in groundwater relate to the term "very hard" water. Soft water is generally water with less than 60 mg/l hardness. The EPA has not set limits on hardness since no specific health threats are known. Hard water can cause scale formation on pipes, fixtures and boilers and often is treated prior to use.

3.2.1.3. Sodium ranges from 20 to greater than 50 mg/l in the NPNRD. Application of irrigation water containing large amounts of sodium increases soil pH and reduces soil permeability over a period of years. Computation of the sodium absorption ratio (SAR) is a means of determining whether sodium content of water is likely to affect soil properties adversely. The ratio is a mathematical combination of sodium (Na), calcium (Ca), and magnesium (Mg). A map showing calcium concentrations in the NPNRD is given as Figure 12-26. Water having an SAR of 10 or greater is said to have a

medium to high sodium hazard (U.S. Salinity Laboratory Staff, 1954). However, the specific soil conditions in a given region must be taken into account in interpreting these values. The SAR values range from 8 to 15 in the alluvium aquifer in the North Platte Valley.

3.2.1.4. Alkalinity can be defined as the capacity of water to neutralize acid. Alkalinity is measured as an equivalent amount of calcium carbonate ($CaCO_3$) and ranges from 0 to over 300 mg/l within the NPNRD (Figure 12-27). Most of the higher concentrations are found in areas where the river water is diverted for irrigation or where the use of groundwater for irrigation is intensive. The recharge due to irrigation water and continuous recycling of groundwater accelerates dissolution of carbonaceous material from soils. If the alkalinity in public water supplies is less than 25 mg/l, chlorination may produce corrosive water that attacks metallic parts of water systems, according to the National Academy of Sciences.

3.2.1.5. Sulfate concentrations in the region vary from 0 to over 100 mg/l (Figure 12-28). Higher concentrations are found along the North Platte River since the alluvium aquifer is hydraulically connected to the river water. Concentrations greater than 250 mg/l may have a laxative effect on some people and that concentration is generally considered an upper limit. Concentrations exceeding 500 mg/l may render water unfit for irrigation by contributing to high salinity. (Reference 74).

3.2.1.6. Boron concentrations in the majority of the NPNRD groundwater vary from 0 to 330 micrograms per liter. Concentrations above 330 micrograms per liter are nearly coincidental with areas of high dissolved solids such as in the Platte River Valley and parts of Banner County. The EPA has set no upper limits since boron is not known to have toxic effects on humans. Boron in small quantities is an essential nutrient for all crops, but even a slight excess over the essential amount is toxic to some crops (U.S. Salinity Lab Staff, 1954).

3.2.1.7. Fluoride occurs naturally in Nebraska's groundwater. The EPA upper limit for fluoride is 1.7 mg/l. Concentrations greater than 1.7 mg/l are known to cause mottling of teeth (McKee and Wolf, 1963), however, lesser concentrations are beneficial in the prevention of tooth decay in children.

3.2.1.8. Selenium

The EPA drinking water regulation for selenium is 0.01 mg/l. Few cases of selenium poisoning from drinking water have been documented. The maladies "blind staggers" and "alkali disease" are caused by high concentrations of selenium and are common in grazing animals. These diseases are generally not caused from drinking water but from ingestion of selenium-accumulator plants such as grain and hay crops grown in selenium-bearing soils. While man is susceptible to these maladies, he is not likely to be affected by them because his food comes from a large variety of areas that may not be seleniferous. Furthermore, cooking volatilizes much of the selenium that would be consumed if the food were eaten raw.

3.2.1.9. Nitrate in the groundwater does present a hazard because it may cause methemoglobinemia (blue baby syndrome) in infant humans and animals. The Environmental Protection Agency has set a limit for nitrate in drinking water of 10.0 mg/l. There is some naturally occurring nitrate in groundwater, however these concentrations are normally small (1-3 mg/l). Excessive concentrations may indicate contamination due to human activities. In recent years the concern over nitrate contamination has increased as the quantity of water fit for domestic uses has decreased. The need to protect groundwater from nitrate contamination is well documented. Nitrate in groundwater needs to be a continuing subject of study and monitoring so that areas with a high potential for contamination can be identified and protected.

There are isolated locations where nitrate contamination has occurred (See Sections 3.1.3 and 3.1.3.2). These areas should be documented and protected from further degradation. Because of the high variability of the geology in the NPNRD, site specific research is necessary.

3.2.1.10. Synthetic organic compounds (SOC's) are another groundwater quality concern. These compounds are being identified in more and more water supplies due to human activities. They include agricultural chemicals such as pesticides and herbicides. Only limited data is now available and more intensive and widespread monitoring of the compounds are needed.

3.2.2. Water Quality in Secondary Aquifers

In earlier discussions it was pointed out that the Chadron Sand could be considered a secondary aquifer in most of the NPNRD. However, it is considered the principal aquifer in isolated parts of Scotts Bluff and Banner Counties (Horseshoe Bend Area). The waters from the Chadron Sand are of a different type from those in the sand and gravel aquifers and from most samples from the Brule Formation. They are very soft, sodium bicarbonate waters with low sulfate and chloride content. Their bicarbonate content is about twice that of the waters in the sand and gravel aquifers and in the Brule formation.

The hard and soft waters differ in other respects, and the difference has a bearing upon the uses for which the waters are adaptable. The soft waters from the Chadron Formation contain a high ratio of sodium salts to calcium and magnesium salts. The average concentration of sulphate in the hard waters is 182 parts per million; whereas, in the soft waters it averages only about 7.5 parts per million (Reference 79).

Water from the Chadron Sand has been shown to have very high concentrations of sodium bicarbonate. Where the sodium content is more than 80% of the total dissolved solids, it is considered to be unsuitable water for irrigation purposes (Reference 79). It is possible that where this type of water is used for irrigation, the precipitation of salts on the land surface may cause such concentrations of alkali that the land may become unfit for agricultural production and even grazing. Water samples from wells in the Chadron Sands indicate a sodium content of 85 to 95% of the total dissolved solids.

These same waters contain boron concentrations from 0.5 to 2.0 milligrams per liter. Boron is an essential element to many plants. According to information from the Conservational Survey Division at UNL, concentrations over 0.33 milligrams per liter are toxic for certain plants.

The quality data collected for these aquifers is limited and should be expanded to obtain a more firm data base to monitor trends, if any occur.

3.2.3. Abandoned Wells

Another area of concern regarding a potential threat to quality of the existing groundwater supply in the NPNRD is not only domestic wells and test holes but mineral exploration and mining, particularly oil, uranium, and geothermal waters. Wells and test holes provide potential sources of groundwater contamination by providing a direct conduit for pollutants to reach groundwater supplies. Literally thousands of abandoned wells and other drilled or dug holes dot the countryside, which could permit dissolved contaminants and other pollutants to migrate into groundwater supplies or which could allow water from one aquifer to mix with different quality water from another aquifer. Similar problems are associated with improperly constructed water supply wells whether they are public or private. The NPNRD's Well Abandonment Program is discussed in Section 8.3.11.

The Nebraska Department of Environmental Quality is specifically authorized to regulate mineral exploration and should be urged to continue development of standards and enforcement in cooperation with the NPNRD. Not only future but existing potential contamination points should be addressed.

3.2.4. Radioactive Contamination

The potential for radioactive contamination has been the subject of recent studies and it appears there may be potential for such contamination in certain formations that occur in the NPNRD.

Uranium is being mined in Dawes County from the Basal Chadron Sand, which according to Figure 12-18 and Reference 98 (DeGraw), underlies a considerable portion of the NPNRD. This report has recognized the Chadron Sand as a principal aquifer in some areas of the NPNRD.

Test holes in the Chadron formation at the Crow Butte Project indicate a mean concentration of radium-226 of 82 pCi/l. The EPA limit for radium-226 is 5 pCi/L. It is again noted that this water quality data was obtained near the Crow Butte Uranium Project area near Crawford and not within the NPNRD. See Section 3.1.3.1 for further discussion of recent radionuclide contamination sampling results in the NPNRD.

3.2.5. Effect of Irrigation Return Flows

The effects of irrigation return flows on groundwater quality have been subject to limited studies in the Dutch Flats area by Babcock and Visher, 1951 (Reference 81). The only comprehensive study which addressed the chemical effects of irrigation return flow of the North Platte River was done during a limited period in August, 1964 by Gordon (Reference 153). The effects of irrigation return flow on water quality in Nebraska was also reported by Walker, 1982 of the Nebraska Department of Environmental Control (DEC, now DEQ), (Reference 99).

Results in the Dutch Flats area indicate the waters are hard and silicious, but are moderately low in mineral content. Water from shallow wells in the seeped area north of Morrill is quite similar to the Dutch Flats water in mineral concentration. Composition of the soil and drainage of the two areas are also similar. All the waters are low in percentage of sodium and are of satisfactory chemical quality for irrigation and domestic use.

Based on the available data as presented in the DEQ report, it appears that irrigation return flows in canal irrigated lands at this time do not generally affect water quality to such an extent that the assigned beneficial uses are impacted. Typically, in areas where there is groundwater recharge to streams, deep percolation of irrigation water has resulted in increases downstream in the concentrations of total dissolved solids, hardness, and various nutrients such as nitrates.

Canal seepage in the North Platte River basin has contributed to the establishment of perennially flowing streams suitable for trout populations. The primary problem identified was that of silty wastewater (tailwater) discharges into Nine Mile Creek which decreased abundance and diversity of benthic invertebrates and affected the distribution of young trout (Reference 99).

Mitigation of the impacts of irrigation return flows on ground and surface water quality can be accomplished by both technical and managerial methods. Irrigation systems should be designed to match the conditions of the site including soil type, topography, field shape, crop type, labor requirement and cost. A number of programs are further discussed in Section 8 of this plan.

The study done by Gordon (Reference 152) although limited to a very short period of time, indicates that the return of irrigation water by groundwater discharge to the North Platte River was largely responsible for a 27% increase in the dissolved solids content of the river between the state line and Bridgeport.

That study was done during a low flow period in that 60-mile reach and the flow of the river was being maintained by return flow. Table 1 in Reference 152 indicates that water entering Nebraska in canals and water from two canals near Bayard was of relatively good quality, i.e., 450 to 550 ppm of dissolved solids, 0.0 to 1.8 ppm of nitrate as NO_3 and 0.7 to 0.11 ppm of phosphate (PO_4). Water entering the state directly from the North Platte River had similar values. Table 2 in Reference 152 shows the results of chemical analyses from four stations on the river and from 24 stations on creeks and drains. The river water increased in concentrations of every constituent except iron and manganese. The increase was greater from the state line to Mitchell than from Mitchell to Minatare. Most of the irrigation return between Minatare and Bridgeport was of better quality than the river water near Minatare.

Nitrate levels from drains were on the order of 5 to 8 ppm with a few values as low as 2 to 3 ppm and as high as 8 to 12 ppm. Phosphates generally showed increases up to double that of the inflow. The weighted average composition of water from tributary drains was 8.2 ppm nitrates and 649 ppm dissolved solids. Gordon suggested that during periods of medium and high flows the percentage increase would undoubtedly be much less than that found in the period of low flow.

In order to ascertain additional baseline surface water quality information and to assess changes that occur between the state line and Lisco, the NPNRD has entered into a cooperative agreement with the U.S. Geological Survey. The reconnaissance study was initiated in May 1992 and will continue during fiscal years 1993-1994 and 1994-1995. One objective of the study is to develop a conceptual model of water quality interactions with the surface water system. Because of the close relationship between surface water and groundwater in much of the NPNRD, the study is expected to provide information helpful in planning approaches to non-point groundwater quality management.

Considerable surface water quality data has been collected for many years by state and federal agencies. Detailed printouts of all the available data has been provided to the NPNRD. The data was obtained from the Natural Resources Commission Data Bank and includes results of partial to rather complete analyses of inorganic and organic chemicals, biological parameters and sediment.

Some records are available on the water quality of Pumpkin Creek at Harrisburg (February 1974 to September 1977), at Bridgeport (July 1969 to September 1972), and near Bridgeport (July 1970 to September 1973). Short term records and analyses of water quality in canals and drains were obtained during the years 1964 to 1979. The term of record in some cases is a single day, others span several months and others several years. The longest record is for the Gering drain near Gering.

Considerable information is available at several stations within the NPNRD along the North Platte River from sampling done by EPA, DEC (now DEQ) and the USGS. The USGS Wyoming District Office collected samples at the Wyoming-Nebraska state line for analyses for a number of field and chemical parameters from August 1964 to January 1987 and since has been reporting mostly field parameters. Sampling and analysis of the North Platte River was done by the USGS at Mitchell in 1964; at Minatare, August 1964 to June 1977; at Bridgeport in 1964 and from 1971 to 1974; at McGrew, June 1973 to September 1989; and at Lisco since March 1970. The Lisco sampling station is one of the USGS national network sampling stations.

Sampling and analyses of the North Platte River by the DEQ illustrates the variability of water quality between sampling stations. Two parameters, conductivity and nitrogen, were selected and are shown in Table 3.2.5-1. Other chemical and field parameters also show variability probably related to volume of discharge, season of year, and stream segment. The length of record at stations varies considerably, as shown. The length of record at Henry (near the state line) and at Lisco are both for the same 20-year period, 1968 to 1988. The mean conductance and nitrate values are quite close. The maximum and minimum values vary considerably, particularly so for nitrates.

A description of the North Platte River basin and water quality for 1990 is contained in Reference 174. With respect to trends, "no significant trends that affect overall water quality were detected in the North Platte River Basin over the past ten years (1979 through 1989)." North Platte River segments near Lisco, near Minatare, and near the state line at Henry showed decreasing organic carbon concentrations and increasing levels of ammonia. Otter Creek, Red Willow Creek and Nine Mile Creek showed increases in total organic carbon. Nitrogen concentrations increased in the North Platte River near Lisco, in Red Willow Creek, in Nine Mile Creek and in

Tub Creek Springs Drain. Concentrations of ammonia also increased in Nine Mile Creek, Winter Creek and Tub Springs Drain. Phosphate concentrations also increased in Otter Creek, Nine Mile Creek and Red Willow Creek.

3.3. Other Potential Areas of Concern for Groundwater Quality

3.3.1. Geothermal Waters

Geothermal resources of Nebraska are identified as Low-Temperature Thermal Waters. They are warm waters at temperatures lower than 100°C, but warm enough to be used as practical heat sources. (Figure 12-29). The lower temperature limit for use depends on the type of application, but in general it is 10°C above the mean annual air temperature.

Low-temperature thermal waters can be used for direct heating (space heating of residences, businesses, complexes, etc.), process heat (ethanol production, food processing, manufacturing) and agribusiness (grain drying, greenhouse heating, livestock warming). The suitability of a given resource depends on temperature and production capabilities, requirements of the user, and economics of the application in comparison to other heat sources.

The following discussion is based on investigations coordinated by the Conservation and Survey Division of the University of Nebraska. The geothermal aquifers are located primarily in the sandstones of the Dakota Group (Cretaceous) which underlies the entire NPNRD. The top of the Dakota Group ranges from approximately 300 to 1700 feet above sea level or about 3,000 to more than 5,000 feet below the ground surface and considerably deeper than any of the principal aquifers used in the NPNRD.

The quality of geothermal waters would not be suitable for any domestic use without extensive treatment.

If and when it is developed, it will be necessary to employ appropriate construction practices to preclude any contamination of the potable water aquifers. The geothermal waters would be transported through the potable water aquifers to the surface for heat extraction and then reinjected into the original geothermal aquifer. The conduit used for extraction of geothermal water should be constructed such that it will not allow migration of water from different aquifers.

3.3.2. Uranium In-Situ Solution Mining

The prospect of uranium mining has increased in the NPNRD with the current development of uranium solution mining in the northern Panhandle near Crawford.

Large deposits of uranium have been discovered in the Chadron Sands which underlie portions of the NPNRD. As discussed earlier, the underlying sands of the Chadron Formation could be classified as a principal aquifer in parts of Scotts Bluff and Banner Counties, with some potential in numerous other locations (See Figure 12-18).

In-situ solution uranium mining is carried out by leaching the uranium from underground ore deposits. A leaching solution is pumped into the ore through patterns of injection wells. The leaching solution dissolves the uranium and is pumped out of the ground by production wells to precipitation tanks or a processing mill. After the ore formation is mined out, the aquifer containing the ore must be restored by one of three techniques: (1) The water is pumped from the aquifer and not returned, (2) contaminated water is pumped out, treated and reinjected, and (3) chemicals are injected into the aquifer in order to precipitate the chemicals that were mobilized during leaching.

One of the greatest concerns with "in-situ" solution mining is the potential for the leaching solution and other chemicals to move outside the intended well field flow patterns causing degradation of groundwater quality. This concern has been recognized by the Nebraska Department of Environmental Quality (DEQ) and they have been working very closely with the developers of the uranium mining facility to preclude such an occurrence. Numerous monitoring wells surround the mining area to continually monitor water quality.

The development of uranium mining could have positive economic impacts on the area, therefore, it is important to understand the concept of the in-situ solution mining technique and how it could affect the use of the Chadron sand aquifer.

4.0 Land Use and Contamination Source Inventory

Land use practices can adversely affect both water quantity and quality. Large withdrawals of groundwater for irrigation, municipal, and industrial use can reduce the amount of groundwater in storage. Groundwater contamination can occur from either point or non-point sources. Point sources of groundwater contamination are many and include; private, community, and industrial type waste disposal systems; the improper use, storage and disposal of chemicals, and other industrial and petroleum products; improperly operated or abandoned livestock feed yards; and improperly sited, constructed and abandoned wells. Non-point sources in Nebraska are generally considered to be those associated with poorly managed agricultural practices such as improper timing and application of fertilizer (either commercial or manure) and farm chemicals in amounts greater than those generally recommended as best management practices. Elsewhere in the state, evidence clearly indicates that poor timing and over irrigation contributes significantly to the contamination of groundwater from agricultural chemicals.

Information presented in this section is taken from the USGS-NPNRD Cooperative Study (Reference 151), referred to in Section 1.1.4, unless otherwise noted.

4.1. Land Use

The NPNRD covers approximately 5,124 square miles in the central part of the Nebraska Panhandle and includes Banner, Garden, Morrill, and Scotts Bluff Counties and the southern part of Sioux County (Figure 12-1). Most of the study area lies in the North Platte River drainage basin. The NPNRD is located in the High Plains section of the Great Plains, and includes the following geographic areas: (1) North Platte Valley, (2) Northern Tablelands, (3) Southern Tablelands, (4) Pumpkin Creek Valley, (5) Wildcat Ridge, and (6) Sandhills Region.

4.1.1. Population Distribution

The population of the NPNRD, amounting to approximately 45,000 people, is concentrated in cities and small towns located along the North Platte River. Table 4.1.1-1 presents the 1990 census figures showing the NPNRD population distribution according to race and county of residence. Table 4.1.1-2 presents the 1980 and 1990 populations of the incorporated cities, towns, and villages within the NRD boundaries. It can be seen from these figures that approximately 68% of the NPNRD population lives within the jurisdiction of 15 cities or towns. The largest incorporated area is the Scottsbluff/Gering/Terrytown area with a population of 22,313, which is 72% of the total town-dwelling population, or 49% of the entire NPNRD population.

The trend toward declining populations in the small towns of Nebraska over the last ten years is also apparent in the NPNRD population figures. Only one town (the City of Gering) has shown an increase in population from 1980-1990 (that being just 2.4%) while all the 14 other incorporated cities and towns showed decreases of 0.6% to 23.2%. Overall, the town-dwelling population of the NPNRD has decreased 4.5% over the years 1980-1990.

Table 4.1.1-1

Race	Banner County		Garden County	Morrill County	Scotts Bluff County		Sioux County	Total
White	832		2,455	5,202	32,822		631	41,942
Black	1	0	1	70	0	72		
Indian	3	0	33		662		1	699
Asian	0	1	7	180	2	190		
Other	16	4	180		2,291		35	2,526
Totals	852		2,460	5,423	36,025		669	45,429

Table 4.1.1-2

Population of Incorporated Towns in the NPNRD

	1980	1990	Percent Change
Bayard	1,435	1,196	-16.7
Bridgeport	1,668	1,581	- 5.2
Broadwater	161	160	- 0.6
Gering	7,760	7,946	2.4
Henry	155	145	- 6.5
Lewellen	368	307	-16.6
Lyman	551	452	-18.0
McGrew	110	99	-10.0
Melbeta	151	116	-23.2
Minatare	969	807	-16.7
Mitchell	1956	1743	-10.9
Morrill	1097	974	-11.2
Oshkosh	1057	986	- 6.7
Scottsbluff	14,156	13,711	- 3.1
Terrytown	727	656	- 9.8
Totals	32,321	30,879	- 4.5

4.1.2. Soils

The major soil associations in the NPNRD and their respective average permeability are listed on the general soil map of Nebraska revised by the Conservation and Survey Division (CSD) in 1990. A generalized soils map based on the Soil Conservation Service (SCS) STATSGO Associations is included in this plan as Figure 12-30.

Most soil associations in the NPNRD appear to be somewhat excessively drained. Only the Gothenburg-Platte-Lawet Association is poorly drained in general and the permeability of the Rosebud-Canyon-Alliance, Alliance-Rosebud-Kuma, Canyon-Rosebud-Rock, Tripp-Mitchel-Alice, and Gothenburg-Platte-Lawet soil associations is slight to moderate (Reference 108).

4.1.3. Industry

In general, industry in the NPNRD is limited to small, local, agriculturally-related manufacturers and distributors. Besides agriculture, three major industries have been identified as having existing or potential applications in the NPNRD. These are: oil and gas production, mineral mining operations, and geothermal resources.

4.1.3.1. 4.11.35.55. Oil and Gas Production

Oil well development has been prominent especially in the western portion of the NPNRD. A map showing the locations of oil and gas exploration and production wells is included in this plan as Figure 12-31. The potential impact of this industry on groundwater quality is discussed in Section 3.2.3 of this plan.

4.1.3.2. Mineral Mining Operations

Most of the mineral mining operations in the NPNRD involve sand and gravel excavation with the majority of these sites located in Banner County, in southern Morrill County, and in the North Platte River Valley. A map showing the location of mineral operations in the NPNRD is supplied as Figure 12-32.

The prospect of uranium mining in the NPNRD has increased with the recent development of a plant for uranium solution mining in the northern Panhandle near Crawford in Dawes County. Although the plant is not located within the NPNRD boundaries, the fact that large deposits of uranium have been discovered in the Chadron Sand Formation, which underlies portions of the

NPNRD, indicate that the potential for uranium in-site mining does exist in these areas. The potential impact of uranium mining on groundwater quality is discussed in Section 3.3.2.

4.1.3.3. Geothermal Resources

The geothermal resources of Nebraska are identified as Low-Temperature Thermal Waters. They are warm waters at temperatures lower than 100°C, but warm enough to be used as practical heat sources. The lower temperature limit for use depends on the type of application, but in general it is 10°C above the mean annual air temperature.

Low-Temperature Thermal Waters can be used for direct heating (space heating of residences, businesses, complexes, etc.), process heat (ethanol production, food processing, manufacturing), and agribusiness (grain drying, greenhouse heating, livestock warming). The suitability of a given resource depends on temperature and production capabilities, requirements of the user, and economics of the application in comparison to other heat sources.

The geothermal aquifers are located primarily in the sandstones of the Dakota Group (Cretaceous) which underlies the entire NPNRD. The top of the Dakota Group ranges from approximately 300 to 1700 feet above sea level or about 3,000 to more than 5,000 feet below the ground surface and considerably deeper than any of the principal aquifers used in the NPNRD. A map showing the distribution of geothermal resources throughout the NPNRD is provided as Figure 12-29.

4.1.4. Agriculture

Agriculture is the primary land-use activity in the NPNRD. According to the Agricultural Stabilization and Conservation Service at least 423,208 acres were cultivated and at least 2,038,241 acres remained rangeland in 1991. Overall, Sioux County had the smallest number of acres set aside for crop production in 1991 (about 6% of the total cropland acreage in the study area), whereas Scotts Bluff County had the largest number of acres set aside for crop production (38.8%). The main dryland crop was wheat (see Table 4.1.4-1). Banner County had the largest number of dry cropland acres in 1991 (about 39.7% of the total dryland acreage) followed by Garden County (about 33%).

Different types of cropland exist in the study area. The main irrigated crops were corn, beets, beans, alfalfa, and wheat (see Table 4.1.4-1). Overall, approximately 67% of the cropland was irrigated in 1991. Scotts Bluff County had the largest number of irrigated acres (about 54.1% of the total irrigated acreage), which consisted of about 15% alfalfa, 22% beans, 23% beets, and 40% corn.

Table 4.1.4-1
Crop Statistics for 1991
Number of Acres by County
(Reference 147)

Crop	Banner	Garden	Morrill	Scotts Bluff	Sioux[1]	Total
Corn, dryland	336	150	640	161	NA	1,287
Corn, irrigated	5,600	14,563	48,574	62,597	12,000	143,334
Wheat, dryland	53,311	42,500	25,202	9,184	0	130,197
Wheat, irrigated	2,000	2,140	1,459	82	1,000	6,681
Beans, dryland	0	183	NA	0	0	183
Beans, irrigated	3,727	2,245	NA	33,000	4,000	42,982
Alfalfa, dryland	603	500	NA	NA	NA	1,103
Alfalfa, irrigated	4,000	7,000	NA	23,231	6,000	40,231
Beets, irrigated	1,571	27	9,487	35,099	2,751	48,935

Others[2], dryland	474	2,163	1,925	438	0	5,000
Others, irrigated	1,510	600	638	467	60	3,275
Total dryland	54,724	45,496	27,767	9,783	0	137,770
Total irrigated	18,418	26,575	60,158	154,476	25,811	285,438
Total	73,142	72,071	87,925	164,259	25,811	423,208

[1]Acres in Sioux County are not restricted to acres within the NRD and include all acres within the county.
[2]Others may indicate oats, rye, sunflowers, cane, potatoes, barley, or sorghum.

4.1.4.1. Agricultural-Related Industry

Agricultural-related light industry in the NPNRD mainly consists of agricultural processing plants, such as sugar-beet processing plants, and livestock businesses. The largest livestock business in the North Platte Valley is cattle production. About 40 feedlots with more than 500 head of cattle each existed in 1991 in addition to many smaller feedlots. Other livestock production includes hogs and sheep.

4.1.5. Wildlife Refuges

The largest wildlife refuges in the NPNRD are the Crescent Lake National Wildlife Refuge in Garden County and the North Platte National Wildlife Refuge in Scotts Bluff County.

4.2. Contamination Sources

Potential groundwater contamination sources in the NPNRD are of two types: Nonpoint Sources (NPS) and Point Sources (PS).

4.2.1. Nonpoint Sources

Nonpoint source (NPS) pollution is defined as pollution caused by diffuse sources that are not regulated as point sources. Normally, nonpoint sources are associated with agricultural, silvicultural, urban and construction site runoff. Such pollution results in the manmade or man-induced alteration of the chemical, physical, biological, and radiological integrity of water. In practical terms, NPS pollution does not result from a discharge at a specific, single location (such as a pipe) but generally results from land runoff, precipitation, atmospheric deposition, or percolation. It must be kept in mind that this definition is necessarily general. Legal and regulatory decisions have sometimes resulted in certain sources being assigned to either the point or nonpoint source categories because of considerations other than the manner of discharge. For example, irrigation return flows are designated as nonpoint sources by Section 402(1) of the Clean Water Act, even though the discharge is through a discrete conveyance. Releases from dams have similarly been defined as nonpoint sources in a federal court decision, even though the discharge is through a discrete conveyance.

Nonpoint sources may generate both conventional and toxic pollutants just as point sources do. Although nonpoint and point sources may contribute many of the same kinds of pollutants, these pollutants are generated in different volumes, combinations, and concentrations. Pollutants from nonpoint sources are mobilized primarily during storm events and the application of irrigation water. Consequently, NPS pollution episodes are generally less frequent and shorter in duration than continuous point source discharges. However, they may contribute to long term problems.

In 1987 Congress amended and reauthorized the Clean Water Act to address current and future water quality problems. The Water Quality Act of 1987 amended the Clean Water Act's declaration of goals and policy by adding the following:

> ... it is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution.

This policy focuses on the importance of controlling nonpoint sources of surface and groundwater pollution. With the enactment of Section 319 of the Clean Water Act (CWA), new direction with federal assistance for the implementation of state nonpoint source programs has been authorized.

Under this program, the NPNRD has developed the "North Platte Valley Water Quality Project Proposal" (Reference 116). This proposal was approved and appropriated Federal Section 319 funds. (See Section 1.1.3 of this plan for a discussion of this program.) The NPNRD plans to address the issue of NPS control through the establishment of a Groundwater Management Area and associated monitoring and control programs. (See Section 9.0.)

In the NPNRD, agricultural activities constitute the most widespread cause of water quality problems from nonpoint sources. Most problems are caused by the application of excessive amounts of fertilizers and/or pesticides and are often exacerbated by the subsequent over-application of supplemental water. Runoff leads to contamination of surface water, while the absorption of these chemicals into the soil leads to the much longer term contamination of the groundwater supply through the slow leaching of these chemicals through successive soil layers.

Although the 1991 Annual NPS Report (Reference 121) by the Nebraska Department of Environmental Quality does not list any areas of the NPNRD as "Areas Reported to be Impacted by Nonpoint Source Groundwater Pollution", this same report does identify the entire North Platte River Valley under "Areas Suspected or with the Potential to be Impacted by Nonpoint Source Groundwater Pollution". A review of the amounts, types of fertilizers and pesticides used in the NPNRD gives an indication of the magnitude of this potential.

4.2.1.1. Fertilizers

The number of acres to which chemical fertilizers were applied in 1987 in each county of the NPNRD are listed in Table 4.2.1.1-1.

Statistics on fertilizer use by volume in the NPNRD are limited to Morrill and Scotts Bluff Counties. Reported fertilizer use in both counties in 1991 was 16,474 tons total nitrogen, 6,564 tons phosphate, and 681 tons potassium. Other fertilizer additions included boric acid (contains boron), copper, zinc, iron, manganese, sulfate, and sodium molybdate (contains sodium and molybdenum) (Reference 147).

Application of chemical fertilizers in excessive amounts or at inappropriate times of the year, especially when combined with excess irrigation, can result in high concentrations of these chemicals and of nitrogen-nitrates in surface water and/or groundwater supplies. Possible identified contamination locations are discussed in Sections 3.0 and 6.0.

Chemigation permits are issued by the North Platte NRD. The following list provides the permit number and the location for all of the chemigation permits granted by the NPNRD in 1992.

PERMIT NO.	QUARTER	QUARTER	SECTION	TOWNSHIP	RANGE	COUNTY
15920108	1/4	NW1/4	18	17N	52W	MORRILL
15920109	1/4	NE1/4	18	17N	52W	MORRILL
15920050	1/4	NW1/4	10	18N	49W	MORRILL
15920038	SW1/4	SE1/4	11	21N	51W	MORRILL
15920006	NW1/4	NW1/4	26	23N	47W	MORRILL
15920245	SE1/4	SW1/4	12	19N	50W	MORRILL
15920246	SW1/4	NE1/4	13	19N	50W	MORRILL
15920247	C1/4	SW1/4	13	19N	50W	MORRILL
15920163	1/4	NE1/4	1	23N	49W	MORRILL
15920079	NW1/4	NW1/4	25	18N	49W	MORRILL
15920098	NE1/4	SE1/4	22	19N	48W	MORRILL
15920099	NE1/4	SW1/4	15	19N	48W	MORRILL
15920070	NE1/4	SW1/4	6	18N	48W	MORRILL
15920071	SW1/4	NW1/4	6	18N	48W	MORRILL
15920023	1/4	SE1/4	23	22N	50W	MORRILL

15920007	SW1/4	NW1/4	12	18N	52W	MORRILL
15920008	NW1/4	SW1/4	12	18N	52W	MORRILL
15920009	SW1/4	SE1/4	11	18N	52W	MORRILL
15920093	NW1/4	NE1/4	29	19N	46W	MORRILL
15920094	NW1/4	NE1/4	29	19N	46W	MORRILL
15920095	NW1/4	NW1/4	29	19N	46W	MORRILL
15920112	SW1/4	NE1/4	12	18N	49W	MORRILL
15920022	SE1/4	NE1/4	25	19N	52W	MORRILL
15920104	1/4	NW1/4	25	19N	52W	MORRILL
15920230	1/4	NW1/4	5	23N	48W	MORRILL
15920279	SW1/4	SW1/4	14	18N	52W	MORRILL
15920032	NW1/4	NE1/4	21	23N	51W	MORRILL
15920179	NE1/4	NE1/4	21	23N	51W	MORRILL
15920034	NE1/4	SE1/4	8	23N	51W	MORRILL
15920033	NE1/4	SE1/4	8	23N	51W	MORRILL
15920051	SW1/4	NW1/4	27	19N	49W	MORRILL
15920052	SW1/4	SW1/4	26	19N	49W	MORRILL
15920053	SW1/4	SW1/4	25	19N	49W	MORRILL
15920054	SW1/4	NE1/4	35	19N	49W	MORRILL
15920055	NE1/4	SE1/4	24	19N	49W	MORRILL
15920292	1/4	SW1/4	23	23N	57W	SCOTTS BLUFF
15920254	C1/4	SE1/4	18	20N	57W	SCOTTS BLUFF

PERMIT NO.	QUARTER	QUARTER	SECTION	TOWNSHIP	RANGE	COUNTY
15920282	SE1/4	SE1/4	12	26N	58W	SIOUX
15920283	W1/4	W1/4	18	26N	58W	SIOUX
15920001	1/4	NE1/4	25	24N	58W	SIOUX
15920002	N1/4	SE1/4	25	24N	57W	SIOUX
15920106	1/4	SE1/4	13	17N	53W	BANNER
15920103	1/4	E1/4	14	17N	53W	BANNER
15920035	1/4	SW1/4	9	17N	56W	BANNER
15920080	1/4	SE1/4	11	19N	54W	BANNER
15920081	1/4	NW1/4	10	17N	57W	BANNER
15920082	1/4	SW1/4	10	17N	57W	BANNER
15920083	1/4	NE1/4	10	17N	57W	BANNER
15920084	SE1/4	SW1/4	3	17N	57W	BANNER
15920085	1/4	SW1/4	3	17N	57W	BANNER
15920024	1/4	SE1/4	19	19N	53W	BANNER
15920025	1/4	NE1/4	29	19N	53W	BANNER
15920026	NW1/4	SW1/4	21	19N	53W	BANNER
15920027	C1/4	NE1/4	28	19N	53W	BANNER
15920028	1/4	SE1/4	22	19N	53W	BANNER
15920029	1/4	SE1/4	24	19N	53W	BANNER
15920030	NE1/4	NE1/4	23	19N	53W	BANNER
15920150	1/4	SE1/4	20	19N	53W	BANNER

15920151	NW1/4	SE1/4	25	19N	53W	BANNER
15920280	1/4	NE1/4	22	19N	53W	BANNER
15920021	1/4	SE1/4	28	20N	58W	BANNER
15920190	1/4	SE1/4	27	20N	58W	BANNER
15920214	SW1/4	SW1/4	2	19N	55W	BANNER
15920277	NW1/4	NE1/4	13	19N	56W	BANNER
15920278	SW1/4	SW1/4	31	20N	54W	BANNER
15920045	SE1/4	SE1/4	2	19N	56W	BANNER
15920046	SE1/4	NW1/4	4	19N	55W	BANNER
15920019	SE1/4	SE1/4	27	20N	58W	BANNER
15920020	SE1/4	NE1/4	34	20N	58W	BANNER
15920003	1/4	SW1/4	6	19N	57W	BANNER
15920004	SW1/4	SW1/4	6	19N	57W	BANNER
15920005	1/4	NW1/4	8	19N	57W	BANNER
15920039	1/4	SE1/4	4	19N	57W	BANNER
15920040	1/4	SW1/4	4	19N	57W	BANNER
15920041	1/4	NW1/4	4	19N	57W	BANNER
15920042	1/4	SE1/4	4	19N	56W	BANNER
15920043	1/4	SW1/4	9	19N	56W	BANNER
15920044	1/4	NE1/4	4	19N	56W	BANNER
15920066	1/4	NE1/4	8	19N	57W	BANNER
15920152	1/4	NE1/4	17	19N	56W	BANNER
15920153	1/4	NW1/4	17	19N	56W	BANNER
15920154	1/4	NE1/4	9	19N	57W	BANNER

PERMIT NO.	QUARTER	QUARTER	SECTION	TOWNSHIP	RANGE	COUNTY
15920155	1/4	NW1/4	9	19N	57W	BANNER
15920156	1/4	SE1/4	6	19N	57W	BANNER
15920114	C1/4	SE1/4	19	18N	58W	BANNER
15920115	1/4	SW1/4	20	18N	58W	BANNER
15920116	C1/4	NW1/4	8	19N	54W	BANNER
15920014	SE1/4	SW1/4	18	19N	53W	BANNER
15920015	SW1/4	SE1/4	18	19N	53W	BANNER
15920016	SE1/4	NE1/4	13	19N	54W	BANNER
15920017	SW1/4	SW1/4	13	19N	54W	BANNER
15920018	SE1/4	NW1/4	24	19N	54W	BANNER
15920105	NE1/4	SW1/4	35	20N	58W	BANNER
15920249	C1/4	SE1/4	26	17N	42W	GARDEN
15920242	SE1/4	SE1/4	27	18N	43W	GARDEN
15920086	NE1/4	SE1/4	17	16N	42W	GARDEN
15920243	C1/4	SE1/4	9	18N	45W	GARDEN
15920244	C1/4	SE1/4	4	18N	45W	GARDEN
15920191	NW1/4	NE1/4	29	19N	44W	GARDEN
15920192	SW1/4	SE1/4	32	19N	44W	GARDEN
15920193	NW1/4	NE1/4	34	19N	44W	GARDEN
15920194	NE1/4	SW1/4	33	19N	44W	GARDEN
15920220	SW1/4	NW1/4	33	19N	44W	GARDEN

15920058	NW1/4	NE1/4	12	16N	42W	GARDEN
15920059	SE1/4	SE1/4	1	16N	42W	GARDEN
15920060	C1/4	NW1/4	1	16N	42W	GARDEN
15920087	NE1/4	NW1/4	32	19N	45W	GARDEN
15920088	C1/4	NW1/4	16	19N	46W	GARDEN
15920089	C1/4	NE1/4	35	19N	46W	GARDEN
15920090	NE1/4	SW1/4	34	19N	46W	GARDEN
15920091	1/4	SE1/4	16	18N	45W	GARDEN
15920092	1/4	SW1/4	16	18N	45W	GARDEN
15920137	C1/4	SE1/4	16	19N	46W	GARDEN
15920061	SW1/4	SW1/4	35	17N	41W	GARDEN
15920062	NW1/4	NW1/4	35	17N	41W	GARDEN
15920063	SW1/4	SE1/4	25	17N	41W	GARDEN
15920064	SW1/4	NW1/4	27	17N	41W	GARDEN
15920075	C1/4	SE1/4	24	18N	44W	GARDEN
15920076	C1/4	NE1/4	24	18N	44W	GARDEN
15920077	C1/4	NW1/4	19	18N	43W	GARDEN
15920078	C1/4	NE1/4	19	18N	43W	GARDEN
15920158	C1/4	SW1/4	19	18N	43W	GARDEN
15920159	1/4	NW1/4	19	18N	43W	GARDEN
15920160	C1/4	NW1/4	30	18N	43W	GARDEN
15920161	NE1/4	SW1/4	30	18N	43W	GARDEN
15920164	C1/4	SW1/4	21	18N	43W	GARDEN
15920248	C1/4	SE1/4	21	18N	43W	GARDEN

PERMIT NO.	QUARTER	QUARTER	SECTION	TOWNSHIP	RANGE	COUNTY
15920241	SE1/4	NE1/4	26	17N	44W	GARDEN
15920301	C1/4	SE1/4	32	19N	45W	GARDEN
15920302	C1/4	SE1/4	8	18N	45W	GARDEN
15920136	C1/4	SE1/4	23	15N	46W	GARDEN
15920235	1/4	SW1/4	16	18N	49W	MORRILL
15920321	E1/4	SE1/4	33	19N	48W	MORRILL
15920317	1/4	NE1/4	14	18N	52W	MORRILL
15920102	SE1/4	NW1/4	32	17N	58W	BANNER
15920097	1/4	NE1/4	3	23N	48W	MORRILL
15920101	NW1/4	SE1/4	6	18N	48W	MORRILL
15920134	SE1/4	SW1/4	8	18N	48W	MORRILL
15920067	SW1/4	NW1/4	32	19N	48W	MORRILL
15920113	SW1/4	SW1/4	2	18N	46W	GARDEN
15920118	1/4	NW1/4	1	18N	46W	GARDEN
15920117	1/4	NW1/4	2	18N	46W	GARDEN
15920047	S1/4	SW1/4	35	23N	53W	SCOTTS BLUFF
15920344	1/4	NW1/4	17	19N	53W	BANNER
15920250	1/4	NE1/4	16	18N	49W	MORRILL
15920255	1/4	SW1/4	9	17N	56W	BANNER
15920010	1/4	SW1/4	9	19N	54W	BANNER

15920012	1/4	NE1/4	7	19N	54W	BANNER
15920036	1/4	SE1/4	3	19N	54W	BANNER
15920013	1/4	SE1/4	7	19N	54W	BANNER
15920308	1/4	NW1/4	6	19N	54W	BANNER
15920011	1/4	SW1/4	6	19N	54W	BANNER
15920065	W1/4	NW1/4	31	18N	46W	MORRILL
15920056	SW1/4	SE1/4	27	18N	47W	MORRILL
15920049	1/4	SW1/4	32	18N	46W	MORRILL
15920068	1/4	NW1/4	5	17N	46W	MORRILL
15920110	1/4	SW1/4	26	18N	47W	MORRILL
15920111	1/4	NE1/4	6	19N	57W	BANNER
15920056	NE1/4	SE1/4	25	22N	52W	MORRILL
15920100	1/4	NW1/4	3	19N	48W	MORRILL
15920195	1/4	SE1/4	23	17N	42W	GARDEN
15920069	NE1/4	SW1/4	19	24N	55W	SIOUX
15920073	C1/4	NW1/4	30	18N	44W	GARDEN
15920072	C1/4	SW1/4	34	18N	44W	GARDEN
15920074	1/4	SW1/4	24	22N	52W	MORRILL
15920048	1/4	SW1/4	14	17N	51W	MORRILL
15920310	NE1/4	NE1/4	2	23N	48W	MORRILL
15920340	NE1/4	SW1/4	13	24N	58W	SIOUX
15920312	1/4	SE1/4	35	18N	44W	GARDEN
15920311	1/4	NE1/4	7	18N	43W	GARDEN
15920232	SE1/4	NW1/4	21	19N	48W	MORRILL

PERMIT NO.	QUARTER	QUARTER	SECTION	TOWNSHIP	RANGE	COUNTY
15920335	1/4	SW1/4	10	19N	54W	BANNER
15920305	1/4	SE1/4	10	19N	54W	BANNER
15920334	1/4	SE1/4	6	19N	54W	BANNER
15920307	1/4	SW1/4	7	19N	54W	BANNER
15920306	1/4	NW1/4	18	19N	54W	BANNER
15920336	1/4	NE1/4	18	19N	54W	BANNER
15920303	1/4	NE1/4	31	25N	57W	SIOUX
15920281	1/4	SW1/4	33	24N	57W	SIOUX
15920327	1/4	NW1/4	4	19N	56W	BANNER
15920326	1/4	SW1/4	3	19N	56W	BANNER
15920328	1/4	NW1/4	19	17N	55W	BANNER
15920329	1/4	SE1/4	19	17N	55W	BANNER
15920330	1/4	NE1/4	19	17N	55W	BANNER
15920331	1/4	NE1/4	11	19N	57W	BANNER
15920332	1/4	SE1/4	9	19N	57W	BANNER
15920333	1/4	NE1/4	7	19N	57W	BANNER
15920337	SW1/4	NE1/4	6	17N	53W	BANNER
15920322	S1/4	SE1/4	4	18N	48W	MORRILL
15920320	NW1/4	N1/4	4	18N	48W	MORRILL
15920323	NW1/4	SW1/4	5	17N	56W	BANNER
15920324	NE1/4	SW1/4	5	17N	56W	BANNER

15920325	NW1/4	SW1/4	19	24N	54W	SIOUX
15920319	1/4	1/4	29	18N	52W	MORRILL
15920315	1/4	NE1/4	22	18N	52W	MORRILL
15920316	1/4	NW1/4	14	18N	52W	MORRILL
15920318	1/4	SE1/4	14	18N	52W	MORRILL
15920316	1/4	NW1/4	14	18N	52W	MORRILL
15920304	1/4	NW1/4	14	19N	54W	BANNER
15920178	1/4	SE1/4	32	24N	52W	SIOUX
15920343	1/4	NE1/4	8	18N	45W	GARDEN
15920341	1/4	NW1/4	21	18N	45W	GARDEN
15920338	1/4	NW1/4	35	18N	49W	GARDEN
15920339	1/4	NW1/4	25	17N	57W	BANNER

4.2.1.2. Pesticides

Agricultural pesticides include herbicides for control of weeds and unwanted plants, insecticides for the control of insects, nematocides for the control of parasitic worms, and fungicides for the control of fungus.

Pesticide use in Nebraska has been projected to be 482 million pounds of active ingredients in 1992. Herbicides account for 84% of the total pesticide use. In Nebraska, approximately 90% of corn, soybean, and grain sorghum acreages are treated with herbicides, of which 57% is applied to corn (Reference 152).

Specific herbicide- and pesticide-use statistics in the NPNRD do not exist for 1991. However, statistics for Nebraska indicate that herbicides were used on about 95% of corn cropland with atrazine (11%) being the most commonly used herbicide statewide. In western Nebraska, 2,4-D was the most commonly used herbicide, and alachlor and atrazine were less commonly used. Other herbicides used on corn were butylate, cyanazine, and metolachlor. The herbicide most commonly used on beans in western Nebraska was ethalfluralin. Herbicides used on wheat in western Nebraska included 2,4-D and dicamba, whereas the herbicides most commonly used on alfalfa were benfluralin and propham. Only about 2.3% of Nebraska's pasture and rangeland were treated with herbicides. The most frequently applied herbicides, insecticides, and nematocides in the NPNRD are listed in Table 4.2.1.2-1 (Reference 152).

Table 4.2.1.2-1
Most Frequently Applied Herbicide and Insecticide on Cropland in the North Plate Natural Resources District
(Reference 152)

Crops	Herbicides	Insecticides and Nematocides
Corn	2,4-D Dicamba (Banvel) Some alachlor and atrazine	Terbufos (Counter) Carbonfuran (Furaden)
Wheat	2,4-D Dicamba (Banvel)	Disulfoton
Beans	EPTC (Eptam) Ethalfluralin (Sonalan)	Carbaryl (Sevin) Disulfoton (Di-syston)
Beets	Ethofumesate (Nortron) Cycolate (Ro-neet)	Dichloropropene (Telone)
Alfalfa	Benfluralin (Balan) Propham (Chem-hoe)	Malathion Carbaryl (Sevin)

In Nebraska, corn has the largest insecticide use followed by grain sorghum. Other crops receive relatively small quantities of insecticide. About 65% of the corn cropland in 1991 was treated with insecticides to combat corn rootworms. In Nebraska, the major insecticides used on corn in 1991 were carbonfuran, chlorpyrifos, and terbufos. Disulfoton was used on wheat, oats, barley, and rye. Carbofuran, chlorpyrifos, and malathion were used on alfalfa. In 1991, insecticide use on pasture and rangeland was almost totally absent in Nebraska and was thought to be totally absent in the study area. Table 4.2.1.2-1 shows the major insecticides and nematocides used in the study area.

In general, corn does not receive much fungicide application. Only an estimated 3.4% of Nebraska's corn acres were treated with fungicides in 1991; the remaining fungicides were applied to specialty crops such as potatoes, sugar beets, and beans. Examples of nematocides are Telone and Temik.

Nematocide use is limited to beets. Fumigants, such as aluminum phosphide, as well as protectants are used on stored grain. Other chemicals include rodenticides and bird repellents (Reference 152).

4.2.2. Point Source

Point sources are sources of groundwater or surface water contamination which can be identified as originating from a specific, small, confined location. Examples of point sources include wastewater treatment plants, feedlots, landfills, septic tanks, leaking underground storage tanks, and abandoned wells.

Nebraska state law gives regulatory control over point sources to the Department of Environmental Quality (DEQ). The Natural Resources Districts have no regulatory power in the point source area, however, the following listing of point source activity in the NPNRD is provided in order to increase awareness of potential problems. These lists are based on current information as of April 1993 and are not intended to be complete and exclusive lists. They are updated regularly by DEQ.

4.2.2.1. RCRIS List

The RCRIS list is a compilation of businesses that are required by the Resource Conservation and Recovery Act (RCRA) to report their activities to the Environmental Protection Agency (EPA). RCRA requires businesses that generate, store or transport hazardous waste to register their activities with the EPA.

Name	City	County
American Tel & Tel Co. Long Lin	Angora	Morrill
Bayard Transcript	Bayard	Morrill
Great Western Sugar Co.	Bayard	Morrill
Puregro Company	Bayard	Morrill
Simplot Soilbuilders	Bayard	Morrill
Bridgeport Equipment Co.	Bridgeport	Morrill

Bridgeport Processing Co.	Bridgeport	Morrill
Bridgeport, City of	Bridgeport	Morrill
E D L Inc.	Bridgeport	Morrill
Morrill County Implement	Bridgeport	Morrill
Morrill County Weed Control	Bridgeport	Morrill
Taylor Flying Service	Bridgeport	Morrill
Great Western Sugar Co.	Gering	Scotts Bluff
Jirdon Agri Chemical Inc.	Gering	Scotts Bluff
Kroon, Richard J.	Gering	Scotts Bluff
Lockwood Corp	Gering	Scotts Bluff
Masek Rocky Mountain Kawasaki I	Gering	Scotts Bluff
Nebraska Transport Co. Inc.	Gering	Scotts Bluff
Russel's Automotive	Gering	Scotts Bluff
Safety-Kleen Corp 6-052-03	Gering	Scotts Bluff
Smith Systems Transportation I	Gering	Scotts Bluff
Western Area Power Administration	Gering	Scotts Bluff
Western Ranch Products Inc.	Gering	Scotts Bluff
Yates Motors	Gering	Scotts Bluff
Kurt Manufacturing Company	Lyman	Scotts Bluff
Puregro Company Unit 434	Lyman	Scotts Bluff
Puregro Company	Mitchell	Scotts Bluff
Western Sugar	Mitchell	Scotts Bluff
Groskopf Mobil Service	Morrill	Scotts Bluff
Jirdon Agri Chemicals Inc.	Morrill	Scotts Bluff
Simplot Soilbuilders	Morrill	Scotts Bluff
Farm and Ranch Fertilizer Inc.	Oshkosh	Garden
Garden County News	Oshkosh	Garden
Garden County Weed Control Aut.	Oshkosh	Garden
Marshalltown Instruments	Oshkosh	Garden
Sun Oil Co.-C W Yount	Scottsbluff	Scotts Bluff
Sun Oil Co.-F W Yount	Scottsbluff	Scotts Bluff
ABCO Transmissions	Scottsbluff	Scotts Bluff
ACE Neon Co.	Scottsbluff	Scotts Bluff
Aluma-Fab	Scottsbluff	Scotts Bluff
Barnett and Ramel Optical Comp	Scottsbluff	Scotts Bluff
Bernards Unlimited	Scottsbluff	Scotts Bluff
Cannon Brothers Ford	Scottsbluff	Scotts Bluff
Case Power & Equipment	Scottsbluff	Scotts Bluff
Chevron USA Inc.	Scottsbluff	Scotts Bluff
Conoco Inc.	Scottsbluff	Scotts Bluff
Contemporary Litho	Scottsbluff	Scotts Bluff
Continental Express BFF	Scottsbluff	Scotts Bluff
CRA Inc.	Scottsbluff	Scotts Bluff
Dalton's Auto Center	Scottsbluff	Scotts Bluff
Eckhardt Cleaners	Scottsbluff	Scotts Bluff
Engstrom Fertilizer & Chemical	Scottsbluff	Scotts Bluff
Farmland Industries Inc.	Scottsbluff	Scotts Bluff

Federal Express Corporation	Scottsbluff	Scotts Bluff
Floyds Sales & Service	Scottsbluff	Scotts Bluff
Gilman Motor Co.	Scottsbluff	Scotts Bluff
Growers, AG Service	Scottsbluff	Scotts Bluff
Heilbrun MFG	Scottsbluff	Scotts Bluff
Ideal Linen Supply	Scottsbluff	Scotts Bluff
Industrial/MIDWEC	Scottsbluff	Scotts Bluff
Kizzier Chevrolet Co.	Scottsbluff	Scotts Bluff
Nebraska Machinery Co.	Scottsbluff	Scotts Bluff
Nebraska Public Power Dis-Bluf	Scottsbluff	Scotts Bluff
Nebraska Public Power District	Scottsbluff	Scotts Bluff
Nebraska Western College	Scottsbluff	Scotts Bluff
Ralphs Aero Spraying Service	Scottsbluff	Scotts Bluff
Reisig Brothers Aerial Spraying	Scottsbluff	Scotts Bluff
Ruan Leasing	Scottsbluff	Scotts Bluff
Scottsbluff Park Dept.	Scottsbluff	Scotts Bluff
Sherwin-Williams Co.	Scottsbluff	Scotts Bluff
Simplot Soilbuilders	Scottsbluff	Scotts Bluff
Star Herald Printing Co. Inc.	Scottsbluff	Scotts Bluff
Stroms, Inc.	Scottsbluff	Scotts Bluff
University of Nebraska-Panhandle	Scottsbluff	Scotts Bluff
Valley Commodities	Scottsbluff	Scotts Bluff
West, Don Aerial Spraying	Scottsbluff	Scotts Bluff
Western Pathology Consultants	Scottsbluff	Scotts Bluff
Western Sugar Company	Scottsbluff	Scotts Bluff

4.2.2.2. CERCLIS List

CERCLIS is an acronym for the Comprehensive Environmental Response, Compensation and Liability Information System. The sites listed on the CERCLIS have been identified by EPA and DEQ as being potentially contaminated with a hazardous substance. EPA may investigate any site on the CERCLIS in accordance with federal regulations.

Name	City	County
Oshkosh Public Water Supply	Oshkosh	Garden
Western Area Power Admin - Foundry Site	Gering	Scotts Bluff
Morrill Landfill	Morrill	Scotts Bluff
Farmland Industries, Inc. - Hastings	Scottsbluff	Scotts Bluff
Reisig Brothers Aerial Spraying, Inc.	Scottsbluff	Scotts Bluff
University of Nebraska - Panhandle Sta.	Scottsbluff	Scotts Bluff

4.2.2.3. <u>NPDES Permits</u>

This list includes applicants or holders of National Pollutant Discharge Elimination System (NPDES) permits for wastewater discharge. (WWTF indicates a wastewater treatment facility.)

Name	City	County
Coral Prod. Corp. (Sing-Heirs)	Harrisburg	Banner
Coral Prod. Corp. (Singleton)	Harrisburg	Banner
Sun Expl. & Prod. Co.-Mossberg	Harrisburg	Banner
Lewellen WWTF	Lewellen	Garden
Oshkosh WWTF	Oshkosh	Garden
Western Sugar Company-Bayard	Bayard	Morrill
Bayard WWTF	Bayard	Morrill
Bell Restaurant Bridgeport	Bridgeport	Morrill
Dudden Sand & Gravel	Bridgeport	Morrill
Bridgeport WWTF	Bridgeport	Morrill
Broadwater WWTF	Broadwater	Morrill
Gering WWTF	Gering	Scotts Bluff
Western Sugar Company-Gering	Gering	Scotts Bluff
Henry WWTF	Henry	Scotts Bluff
Lyman WWTF	Lyman	Scotts Bluff
Melbeta WWTF	Melbeta	Scotts Bluff
Minatare WWTF	Minatare	Scotts Bluff
Mitchell WWTF	Mitchell	Scotts Bluff
Western Sugar Company-Mitchell	Mitchell	Scotts Bluff
Morrill WWTF	Morrill	Scotts Bluff
Atsco Inc.	Scottsbluff	Scotts Bluff
Terra Resources, Inc.	Scottsbluff	Scotts Bluff
CRA Inc.	Scottsbluff	Scotts Bluff
Carl D. Underwood Oil & Gas Co.	Scottsbluff	Scotts Bluff
NPPD Bluffs Station	Scottsbluff	Scotts Bluff
Dale Cannon	Scottsbluff	Scotts Bluff
Scottsbluff WWTF	Scottsbluff	Scotts Bluff
Western Valley Packing Co.	Scottsbluff	Scotts Bluf
Western Sugar Company- S. Bluff	Scottsbluff	Scotts Bluff
East Portal "66"	Scottsbluff	Scotts Bluff
Terrytown WWTF	Terrytown	Scotts Bluff

4.2.2.4. <u>Feedlots</u>

Following is a listing of feedlots in the NPNRD.

Operation	County
Hoehn Farms, Inc.	Banner
Hoehn Farms, Inc.	Banner
Hoehn Farms, Inc.	Banner
Darnall Ranch, Inc.	Banner
Barrett, Ronald	Banner
Waldo Western Breeders	Garden
Nuss Feedlot	Morrill
Little, Gary	Morrill
Pappas, Steve G.	Morrill
Stuart, Bill	Morrill
Dinklage Feedyard, Inc.	Morrill
Newkirk, Rick & Margret	Morrill
Newkirk, Rick & Margret	Morrill
Valley Stockman	Morrill
Sand Hills Beef, Inc.	Scotts Bluff
Minatare Feedlot, Inc.	Scotts Bluff
Bill Stuart, Inc.	Scotts Bluff
John R. Jirdon Industries, Inc.	Scotts Bluff
Dinklage Feeding Company	Scotts Bluff
Rosenau, Jane	Scotts Bluff
Larsen Feeding Corp.	Scotts Bluff
Cook, John	Scotts Bluff
Kaman, Bruce	Scotts Bluff
Kaman Farms, Inc.	Scotts Bluff
Seip, Keith	Scotts Bluff
Floyd Engleman Livestock	Scotts Bluff
Panhandle PIG Corp.	Scotts Bluff
Lutz, Steve	Scotts Bluff
Walker Farms, Inc.	Scotts Bluff
Deboer Land & Cattle	Scotts Bluff
Ankony Shadow Isle Ranch	Scotts Bluff
Carlson Feeding Company	Scotts Bluff
Western Pork	Scotts Bluff
Hort, Phillip	Scotts Bluff
Ullrich Livestock	Scotts Bluff
Hutchinson Livestock	Scotts Bluff
Miller, Marvin	Sioux
Bluestem Pork	Sioux
C. D. Hergert	Sioux

4.2.2.5. Landfills

There are only two active licensed landfills in the NPNRD. They are listed on the following page.

County	Landfill Name	Tons Disposed (1990)	Expected Life (Years)	Active (Acres)	Design (Acres)	Closed (Acres)
Scotts Bluff	Gering Disposal Area	13,100	20	5	40[1]	0
Scotts Bluff	Scottsbluff Disposal Area	27,500	45-50	7	60	0

[1]Precise design figure not available. Reported acreage available is listed.

In addition, within the NPNRD there are five unlicensed community solid waste disposal sites that are scheduled for additional study by the DEQ. These sites are in the following communities: Oshkosh in Garden County, Bridgeport and Broadwater in Morrill County, Minatare and Mitchell in Scotts Bluff County. There are no unlicensed solid waste facilities in the NPNRD that have been closed or are in the process of being closed by the DEQ at this time.

4.2.2.6. Compost Facilities

There are no public composting facilities in the NPNRD as listed by DEQ.

4.2.2.7. LUST Sites

LUST is an acronym for Leaking Underground Storage Tanks. The LUST report is a listing of all of the leaking underground storage tanks in the NPNRD reported to DEQ since 1981. The list identifies the type of release for each site. The LUST list is arranged by city, and is updated monthly.

City	Spill Location	Material
Bayard	645 Main Street	Regular
Bayard	21N, 52W, 35 BCC	Gasoline
Bayard	724 4th Street	Gasoline
Bayard	344 Main Street	Gasoline
Bayard	144 Main Street	Gasoline
Bridgeport	Alley E of Main/700-800 Block	Gasoline

Bridgeport	702 Main		Gasoline
Bridgeport	Int Hwy 26 & 385		Gasoline
Bridgeport	Bridgeport Coop		Gasoline
Bridgeport	501 Main St.		Gasoline
Bridgeport	East Hwy 385		
Bridgeport	750 Ft E Main Xing S Track	Gas	
Bridgeport	8th & J Street	Gas	
Bridgeport	RR Yard		Petroleum
Broadwater	Broadwater		Gas
Broadwater	Broadwater, NE		Gasoline Diesel Fuel
Gering	785 Rundell Road		Diesel
Gering	2013 10th Street		Gasoline
Gering	G&R Service 1300 10th Street	Gasoline	
Gering	Big Red Liquor-500 "M" Street	Gas	
Gering	950 U Street		Gasoline
Gering	880 E. Country Club Road		Gasoline/Diesel
Gering	11th & M		
Gering	1165 10th Street		Gasoline
Gering	2055 10th Street		Gasoline
Gering	1165 10th Street		Gasoline
Lewellen	East Hwy 26		Gas
Minatare	411 Main Street		Gasoline
Minatare	Hwy 26 Ease		Unleaded Gasoline
Minatare	Dinklage Feeding (Granada)	Gasoline	
Mitchell	1145 Fourteenth Street		Gasoline
Mitchell	18th & Broadway		Gasoline
Mitchell	--		Gas & Diesel
Mitchell	W of Jct. Hwy 26/29		Gasoline
Mitchell	Research Center		Gasoline
Mitchell	18th & Broadway		Gasoline
Mitchell	1203 Broadway Street		Gasoline
Mitchell	Mitchell		Gasoline
Morrill	Morrill		
Morrill	County Rd. & McKinley		Diesel
Morrill	Jirdon & McKinley		Gasoline
Morrill	Hwy 26 & County Rd L-79D	Unleaded Gasoline	
Morrill	Madison & Webster St.		Unleaded & Regular Gas
Morrill	S Morrill UPRR Yard		Diesel
Oshkosh	Lewellen		Gasoline
Oshkosh	223 Main Street		Gasoline
Oshkosh	2nd & Hwy 26 (Next to Dougs Tex)		Gasoline & Diesel
Oshkosh	Hwy 26 & 27	Gasoline	
Oshkosh	101 West B Street		
Oshkosh	Hwy 26 & 27	Gasoline	
Scottsbluff	1201 Ave 1/Bypass to Gering	Diesel & Gasohol	
Scottsbluff	Hwy 26		Gasoline & Diesel

Scottsbluff	506 S. Beltline-Ideal Laundry	Gasoline	
Scottsbluff	2430 Ave 1		Waste Oil
Scottsbluff	East Portal 66	Gas	
Scottsbluff	609 5th Ave.		Gasoline Diesel
Scottsbluff	1110 Ave. B		Diesel
Scottsbluff	1105 3rd Ave.	Gasoline	
Scottsbluff	624 W 20th		Gasoline
Scottsbluff	1918 E 20th Place		Gas/Diesel
Scottsbluff	2022 East 17th St.		Gasoline
Scottsbluff	1015 Ave 1		Gasoline
Scottsbluff	1802 E. Overland		Gasoline
Scottsbluff	--		Gasoline
Scottsbluff	1015 Ave 1		
Scottsbluff	322 S. Beltline Hwy 3		Waste Oil
Scottsbluff	Muni Well 12th & Overland Street		Gasoline
Scottsbluff	1 Mile S KOA Campground		
Scottsbluff	2000 W Overland Drive		Gasoline
Scottsbluff	Country Corner KOA		Gasoline

4.2.2.8. Septic Tanks

Septic tanks are a known point source of groundwater contamination and are a growing concern, especially in rural subdivisions. However, since registration of septic tanks is not required, no data on locations or density of septic tanks in the NPNRD is currently available.

4.2.3. Wellhead Protection Areas

The following communities in the NPNRD have DEQ delineated Wellhead Protection Areas around their drinking water wells: Bridgeport, Gering, Lyman, Minatare, Mitchell, Scottsbluff, Wagon Wheel Trailer Court (Scottsbluff). See Section 8.3.13 of this plan for further discussion of Wellhead Protection Areas.

4.3. Identified Needs and Deficiencies

An urgent priority is to determine the best management practices (BMP) for use of crop nutrients and pesticides. Irrigation water management practices will be emphasized. The section "Measures of Success" in the North Platte Valley Water Quality Project proposal is an excellent presentation of BMP's which can be applied.

An important priority from the 1986 GWMP is to determine the relationship between the quality of surface irrigation water and the quality of underlying groundwater. This program would require a closely coordinated joint effort among the NRD, surface irrigators, and the large number of irrigation districts in the area and may involve the National Water Quality Assessment (NAWQUA) project by the USGS.

Provisions should be made for sampling surface water at strategic locations in streams and drains that carry irrigation return flow. The current investigation of the University Lake area should provide some data.

Sampling locations should include wells that are located in close proximity to irrigation canals or tailwater canals. The highly permeable soils in the irrigation areas allow a fairly large amount of water to percolate down to groundwater which eventually returns to the river and is again diverted from the river for irrigation. This cycle may occur numerous times between the upstream areas in Wyoming and the NPNRD projects. Research should be encouraged to determine if the recycling of water has any effect on the groundwater quality in the NRD. Base data is contained in USGS Professional Paper 550-C, 1964, by G.V. Gordon on "Chemical Effects of Irrigation Return Water, North Platte River, Western Nebraska".

5.0 Water Use and Demand

Demands are made on the groundwater reservoir within the North Platte Drainage Basin for many purposes. Among these are demands for rural domestic uses, municipal uses, livestock, crops, industries, cooling water for power generation, sub-irrigation of wetlands vegetation, and stream flow for fish and wildlife habitat. Comments on the projected uses of each are based on information from the 1985 Policy Issue Study on Water and Energy by the NRC.

Table 5.0-1 lists the total withdrawals from groundwater sources for public water supplies and breaks down the usage of that water into Domestic, Commercial, and Industrial categories.

5.1. Domestic Use

Rural, domestic, and livestock groundwater demands are made by rural residents to serve the daily needs of their families and livestock. Groundwater is normally supplied for these purposes by small capacity wells ranging from 5 to 20 gpm. Rural domestic and livestock demands do not represent a large portion of the total groundwater demand, but they are very important because of health and economic concerns. If nitrate or bacterial contamination occurs, the health of both residents and livestock is threatened.

Municipal groundwater demands include use of water for domestic purposes, sanitation, fire protection, commercial and industrial purposes, gardening, etc. In 1980, 15 municipal systems in the North Platte River Basin used 16.55 million gallons of groundwater per day or a total of about 18,500 acre-feet demand per year. Progressive development in almost all municipal systems is projected to occur.

The quality of groundwater for municipal purposes must meet the chemical requirements for public water supplies as prescribed by the State Health Department. Currently the most serious quality concern of most communities is excessive nitrate concentrations in water supplies. Nitrate concentrations exceeding 10 parts per million (ppm) are dangerous to infant children and infant animals. The total annual municipal demand of approximately 18,500 acre-feet is small compared to the total overall demand, but the quality of municipal supplies is critical for the health and economic well being of the North Platte River Basin.

Tables 5.1-1 through 5.1-3 list 1985 estimates of total domestic water use in the NPNRD, both from public-supplied and from self-supplied groundwater sources.

9.

5.2. Agricultural Use

5.2.1. Groundwater

Crop groundwater demand is the quantity of irrigation water needed to supplement natural precipitation in raising a crop. Irrigation groundwater demand varies from year to year depending on the amount of rainfall received. Based on crop requirements and the number of acres of each type planted in the basin, current annual groundwater irrigation requirements in the North Platte River Basin are approximately 163,400 acre-feet per year assuming normal precipitation occurs. However, the majority of irrigation water supply in this basin comes from canal surface water. These requirements total 1.275 million acre-feet per year. Surface water irrigation is discussed in Section 5.2.2.

A 1985 estimate of the total water used for irrigation in the NPNRD is shown in Table 5.2.1-1. The number of registered irrigation wells in the NPNRD as of 1985 is listed in Table 5.2.1-2. The amount of groundwater withdrawn by these wells, further broken down into center pivot distribution systems and gravity distribution systems is listed in Tables 5.2.1-3 and 5.2.1-4, respectively. Locations of registered irrigation wells in the

NPNRD are shown on Figure 12-33. Locations of center-pivot irrigation systems are shown on Figure 12-34.

9.

Sub-irrigation groundwater demands include groundwater which is withdrawn directly from the water table by vegetation. Sub-irrigation occurs in the wetland areas where the depth to the water table is quite shallow. Sub-irrigation areas produce lush native grass for hay and also support trees and other vegetation all of which use significant quantities of groundwater. In some areas where the water table is not too shallow (5 to 20 feet deep) cropping of sub-irrigated areas can be accomplished. Based on data for plant water requirements and inventories of wetland areas, it is estimated that the sub-irrigation groundwater demand of the North Platte River Basin is 350,000 acre-feet per year (Reference 179).

Streamflow groundwater demand includes the groundwater discharge which is necessary to maintain normal base flows in streams. As stated earlier, water in the North Platte River Basin enters Nebraska via the river and valley alluvium from controlled discharge in Wyoming reservoirs. Nearly 1.5 times the water entering Nebraska in the North Platte River enters in irrigation canals. The marked downstream increase in discharge in the reach from the state line to a point a short distance beyond Bridgeport is due to the large contribution of groundwater to stream flow. Seepage losses from the irrigation water distribution systems and from irrigation water applied to cropland has, over the years, created a groundwater reserve, beneath the broad terraces in this part of the North Platte Valley. This reserve, which did not exist before surface irrigation, supports a nearly steady outflow to the North Platte either directly to the river or to streams and man-made groundwater drains that are tributary to it. It is estimated that nearly 500,000 acre-feet of groundwater per year is returned to the North Platte River.

Table 5.2.1-5 lists the number of registered irrigation wells in the NPNRD by year. Prior to 1953 there were only about 260 irrigation wells in the North Platte NRD. Most of the wells were in the North Platte River Valley, and 165 of these wells were in Scotts Bluff County. The number of wells registered increased rather dramatically in the next five years to 1958 and again in the five-year period from 1973 to 19778. The location of registered irrigation wells is shown in Figure 12-33. The total number of registered irrigation wells in the North Platte NRD at the end of 1992 is 2,062.

Table 5.2.1-5
Registered Irrigation Wells in The North Platte NRD[2]

Year	Banner	Garden	Morrill	Scotts Bluff	Sioux[1]	Total
1936	1	N/A	N/A	36	6	43
1942	13 20	26	76	6	141	
1948	20 20	26	78	9	153	
1953	28 21	35	165	11	260	
1958[2]	53 61	92	260	67	533	
1963	51 73	139	287	75	625	
1968	69 91	193	316	85	754	
1973	102 130	276	333	95	936	
1978	175 260	504	425	175	1,539	
1983	234 291	601	445	206	1,777	
1988	249 301	622	459	214	1,845	
1992	267 315	682	555	243	2,062	

1 Numbers of wells prior to 1991 include all wells in Sioux County.
2 Data before 1958 from Conservation and Survey Division files; after 1958 the data are from well registrations reported to the end of the year by the Department of Water Resources.

Using published projections for population, irrigation development, and industrial development, it is projected that groundwater demands will increase over the next 20 years as follows:

Groundwater Use	Current[1] Demand (Acre-Feet)	Projected 2005[2] Demand (Acre-Feet)
Rural Domestic and Livestock	7,100	8,500
Municipal	18,500	21,150
Crop Irrigation	163,000	201,280
Industrial (Self-Supplied)	4,800	5,970
Power Generation	9,850	9,850
Sub-Irrigation	350,000	350,000
Stream Flow	500,000	500,000
Total Annual Groundwater Demand[1]	1,053,650	1,096,750

1 Data taken from Nebraska Water Survey Papers 48 and 54. Demands based upon normal precipitation occurring (Reference No. 2 and 3).

[2] Projection based on State Projections from the 1984 Policy Issue Study on Water and Energy published by the NRC (Reference 104).

The quality of water used for irrigation must be good in order for profitable yields to be obtained. Groundwater irrigation is projected to increase, however, large increases may be dependent on the degree of profitability realized.

The report on the Framework Study, 1971, of the State Water Plan notes that most of the basin's irrigable land with a water supply which can be economically developed has already been developed. Future irrigation development will be mostly from groundwater. Some development of scattered tracts in the valley interspersed among the existing irrigation parcels is anticipated. Surface irrigation demand is not expected to increase appreciably.

5.2.2. Surface Water

The amount of surface water used for irrigation in the NPNRD is approximately seven times the amount of groundwater used for that purpose. Tables 5.2.2-1 and 5.2.2-2 list the estimated use of surface water for irrigation based on withdrawal permits issued by DWR in 1985. The majority of this water is taken from a system of irrigation canals in the North Platte River Valley and from Pumpkin Creek, a major tributary to the river. Regulation of surface water irrigation in the NPNRD is under the jurisdiction of 28 local irrigation districts (Figure 12-35).

5.2.2.1. North Platte River

Table 5.2.2.1-1 and Figure 5.2.2.1-1 represent a review of the annual surface water supplies and diversions for irrigation in the NPNRD for a 20 year period 1971 - 1990. Table 5.2.2.1-1 is an annual numerical listing of values in acre-feet, and Figure 5.2.2.1-1 is the same information in a bar graph format. The data was obtained from the Natural Resources Commission data bank, assembled from information provided by the Department of Water Resources (DWR).

Column 1 in Table 5.2.2.1-1 is the amount of surface water in acre-feet crossing the Nebraska-Wyoming state line annually for the 20 year period. The amount listed is the sum of the No. Platte River at the state line, Horse Creek, Mitchell-Gering Canal, Fort Laramie Canal, and the Interstate Canal at the state line. Some of the flow values are estimated in the absence of state line gages. Actual gaged values were available for the No. Platte River, Mitchell-Gering Canal, and Horse Creek. However, the Horse Creek gage is four to five miles east of the state line. Gaged values were available for the Fort Laramie Canal only for the years 1981-1990. Previous years state line flow (1971-1980) were estimated on the basis of headgate diversions at the Whalen diversion dam, percentage of lands irrigated in Wyoming and Nebraska and main canal losses in Wyoming and comparison with the period of measured values. The Interstate Canal is measured near the Whalen

Diversion Dam, but not at the state line. The values used for state line flow of the Interstate Canal were estimated using the measured headgate diversion at Whalen diversion dam, percentage of land served in each state, main canal losses, and the Fort Laramie Canal comparison.

Column 2 of Table 5.2.2.1-1 is the annual contribution in acre-feet of 19 streams and drains tributary to the North Platte River in the NPNRD as measured by the DWR during the 20 year period 1971-90. Of the 19 tributaries, 12 are measured continuously through the entire year, while seven are measured only during the five month irrigation season May 1 to September 30. There is, of course, additional tributary inflow to the river from small streams and drains which are not measured by DWR.

Column 3 of Table 5.2.2.1-1 is the total annual diversions in acre-feet by 27 canal systems which are delivering irrigation water to Nebraska land in the NPNRD and are measured by the DWR. These canal systems are the Interstate, Ft. Laramie, Mitchell-Gering, Tri-State and Northport, Enterprise, Winters Creek, Central, Minature, Castle Rock-Steamboat, Nine Mile, Short Line, Chimney Rock, Alliance, Belmont, Empire, Browns Creek, Court House Rock, Last Chance, Meredith-Amer, Beerline, Lisco, Midland-Overland, Paisley, Blue Creek, Hooper, Union and Graf Canal. There are many other small diversions for irrigation from the North Platte River and tributaries such as stream pumps and small private canals. However, these are not measured by the DWR. Those amounts are considered insignificant, probably less than one percent of the amounts diverted by the 27 canal systems. Acreage reports to DWR indicated that 342,590 acres were intended to be irrigated during the 1992 irrigation season by the 27 canals. The actual number of acres irrigated from surface water sources appears to be significantly less than the number reported to DWR (See Table 5.2.2-1).

Column 4 of Table 5.2.2.1-1 is the measured values in acre-feet of the North Platte River at Lewellen, representing the flow across the east boundary of the NPNRD. The average annual flow entering Lake McConaughy for the 20 year period 1971-1990 was 1,265,770 acre-feet, an increase of 34% over the 29 year period 1942-1970 when the average annual flow was 945,500 acre-feet.

The amount of surface water inflow across the state line for the 20 year period 1971-1990 was greatest in 1983 and 1984, being about 2.6 and 2.9 million acre-feet respectively. The flows in 1989 and 1990 were the least, about 0.84 and 0.62 million acre-feet, respectively, for these years. The annual average was about 1.4 million acre-feet. The amount of flow is mostly dependent upon annual precipitation (largely snowfall) and to some degree upon antecedent storage in the Wyoming reservoirs. In general, in the years with abundant snow pack, the inflow is about double the average, and in the years with low snow pack, about one-half the average.

Figure 5.2.2.1-2 is an illustration of North Platte River tributary inflows in western Nebraska for an earlier time period, 1911-1972. The study reach includes that part of the river from the stateline to Bridgeport, where most of the tributary inflows occur in the NPNRD. The graph is taken from the 1971-72 Hydrographic Report published by DWR. This graph clearly illustrates the large increase of tributary inflows to the river following construction of reservoirs in Wyoming (Pathfinder in particular) by the U.S. Bureau of Reclamation, and also the Interstate, Ft. Laramie and Northport Canal Systems. This was known as the North Platte Project and was constructed in the 1910-1915 era.

The amount of North Platte River outflow across the eastern boundary of the NPNRD into Lake McConaughy averaged about 1,266,000 acre-feet annually during the 20 year period 1971-90. This amount is about ten percent less than the flow at the state line. The measured canal diversions by the 27 canals averaged about 1.03 million acre-feet annually during the 20 year period, ranging from a high value in 1985 of 1.21 million acre-feet to a low value in 1990 of 0.75 million acre-feet. The measured tributary inflow has been consistently about 0.5 million acre-feet annually with the exception of the last two years of the 20 year period when the flow was about 0.4 million acre-feet in 1989, and about 0.35 million acre-feet in 1990. Most of the measured tributary inflow is return flow from water previously diverted through the canals for irrigation. Some of the return flow is overland runoff, and some is via groundwater (see Section 2.1.2.4.1 on Groundwater/Surface Water Relationships).

5.2.2.1.1. Adjudication Process

In recent years DWR has been adjudicating water rights throughout the state. Table 5.2.2.1.1-1 shows the results of adjudicating the water rights of canal systems in the eastern half of the NPNRD in recent years. Adjudication of water rights elsewhere in the NPNRD are expected in the future.

Table 5.2.2.1.1-1
Results of Adjudication of Water Rights

Canal	Water Rights (in cfs)		
	Before Adjudication	After Adjudication	Incidental Underground Storage
Belmont (Bridgeport Irr. Dist.)	270.8	90.4	0
Empire Canal	31.6	29.2	0
Browns Creek	188.7	59.9	27.6
Court House Rock	31.0	19.6	0
Last Chance	6.3	2.6	0
Meredith-Ammer	14.0	4.8	0
Beerline	30.0	14.0	0
Lisco	63.0	37.5	16.5
Meredith-Overland	29.2	24.4	0
Paisley	24.6	15.4	0
Blue Creek	186.1	38.5	0
Hooper	12.0	12.0	0

Union	23.4	16.0	0
Graf (Meeker Irr. Dist.)	31.6	11.4	0

The adjudication process is that of determining the number of acres currently being served under each water right that has been granted over time. For various reasons the lands originally served or intended to be served may not now be served, and thus water rights to them are subject to cancellation or modification. Canal operators or owners may apply for incidental underground storage rights and may, if granted by DWR, obtain a right for diverting quantities of surface water for underground storage purposes. Legislation passed in 1985 (LB-198) and modified subsequently (Chapter 46, Sections 226, 233, 240, 241, 242 and 297) provides the potential for integrated management of groundwater and surface water. Only two districts in the NPNRD, Lisco Irrigation District and the Browns Creek Irrigation District, have applied for and received a water right for incidental underground water storage. The other canal systems listed in the table did not apply to divert water for incidental underground storage purposes.

The role of the NPNRD with respect to surface water diversion is limited. However, the district could be an applicant to obtain a surface water right for various purposes. The district can adopt rules and regulations with respect to groundwater withdrawal and groundwater protection. Chapter 46, Section 666.01 is specific in requiring a Natural Resources District to consult with holders of any permits for intentional or incidental groundwater storage and recovery pursuant to Section 46-226.02, 46-233, 46-240, 46-241, 46-242, or 46-297 prior to adopting or amending any rules or regulations for a management area pursuant to Section 46-673.09. Provisions of Section 46-673.-09, which authorize a district to manage the use of water in a management area, include a provision for requiring best management practices.

A role for the NPNRD could be to provide information to any group considering an incidental recharge application and perhaps assisting in the preparation of an application.

State law would appear to permit an NRD to apply for a surface water right for storage and/or other facilities to intentionally recharge groundwater. In this regard, the NRD could cooperate with other water suppliers in water management efforts involving either incidental or intentional groundwater recharge including the recovery of water.

5.2.2.2. Pumpkin Creek

The amount of water in Pumpkin Creek has declined significantly as shown by Figure 5.2.2.2-1, which graphs the annual discharge of the stream for the years 1942-1990. The average annual yield of Pumpkin Creek for the 29 year period 1942-1970 was 23,900 acre-feet, and the average annual yield for a more recent 20 year period 1971-1990 was 12,100 acre-feet, a decline of nearly 50%. These values are the flow of Pumpkin Creek at the gaging station near Bridgeport where it enters the North Platte River.

The stream has been grossly over-appropriated with water rights which has required regulatory administration annually. In 1979, the Department of Water Resources adjudicated the water rights on the stream canceling 34 cubic feet per second (cfs) from the water rights system. The stream remains grossly over-appropriated with rights in effect for more than 92 cfs, while the mean daily discharge of the stream for the period 1971-1990 is only 16.7 cfs. Water rights for storage total about 530 acre-feet for several small reservoirs which are mostly located in the western or upper part of the Pumpkin Creek basin.

5.3. Industrial Use

Industrial groundwater demands include water which is public-supplied or self-supplied by industry for processing, sanitation, raw material, etc. In 1980, ten self-supplied industries in the North Platte River Basin used 4.32 million gallons per day or 4,800 acre-feet per year from groundwater and 6.2 million gallons per day or 7,000 acre-feet from surface water. Good water quality is critical to the success of many manufacturing processes. Poor quality water can damage manufacturing equipment and may increase production costs to a point where production is economically unfeasible. Industrial growth is continually being pursued and such growth will increase water demand. Some of the largest water users are meat packers, sugar processors, and fertilizer manufacturers.

Power generation groundwater demands include water which is used to cool generating equipment and aid in the efficient production of power. In 1980, 8.8 million gallons per day or approximately 9,850 acre-feet per year was used for power generation purposes.

Table 5.3-1 lists 1985 estimates of water use for commercial, industrial, and mining purposes in the NPNRD.

5.4. Fish and Wildlife Needs

The North Platte River Valley provides habitats for a number of species of fish, mammals, water fowl, birds, and migratory birds. Stream flow in the river and the interrelated groundwater supply has a significant impact on these habitats.

The North Platte River in Nebraska is classified as a Class I stream (Class I highest value and Class IV lowest value) from Lake McConaughy upstream to the stateline. This reach of the river serves as a corridor for rainbow trout migration from Lake McConaughy to important spawning tributaries in the Bridgeport to Henry reach of the river. These migrating rainbows average three to four pounds in size. Warm water gamefish, such as channel catfish, largemouth and smallmouth bass, sunfish, crappie, northern pike, and walleye, can be found throughout the North Platte in Nebraska. Lake Minatare is considered a walleye fishery of local and regional significance.

The Policy Issue Study on Instream Flows, 1982, (Reference 182), contains a table of recommended fishery flows for the upper reaches of the North Platte River. The flows vary each month of the year. The study also includes a map of the state with a legend showing the North Platte river having a designation as a stream with continuous flow throughout the year, significant instream flow values, and base flows that are entirely committed to existing water rights for out-of-stream uses (at least seasonally).

The North Platte National Wildlife Refuge several miles north of Scottsbluff, Nebraska annually supports over 100,000 mallards during the late fall and early winter months, until the open water habitat provided by irrigation reservoirs freezes over. Much of the North Platte River serves as wintering habitat for waterfowl, particularly the reaches in the vicinity of Lake McConaughy and the reservoir itself. A State waterfowl refuge exists in Garden County, and a State wildlife management area, primarily for waterfowl, are both located above Lake McConaughy. Crescent Lake National Wildlife Refuge is also located in the Sandhills region of Garden County.

According to a letter dated August 10, 1992, from Mary Clausen (Nebraska Game and Parks Commission) to Ron Cacek (NPNRD Manager), no federally listed threatened or endangered fish or wildlife species, and no potential habitat for threatened or endangered species exist within the jurisdiction of the North Platte NRD. However, local residents have reported the existence of Bald Eagles and Swift Foxes in the Platte River Valley, both of which may be impacted by groundwater management plans.

5.5. Recreational Use

Lake Minatare provides a variety of water based recreational opportunities. Lake Alice, once a source of recreational opportunity, has been essentially closed and public access has been practically eliminated. The channel of the North Platte river, and its tributaries, provide fishing opportunities. The Sandhills area, including the Crescent Lake Wildlife Refuge, offers a variety of activities related to recreational water use.

5.6. Economic Value of Water

In order to prioritize the uses of water for purposes of better management, the relative economic value of alternative uses needs to be evaluated. As competition for available water increases in the future, the economic value of the use will likely be an important factor in managing development of facilities which have higher water demands.

Groundwater is the economic lifeblood of the North Platte NRD. If the groundwater supply were to deteriorate substantially in either quantity or quality, competition for the remaining usable supply would likely be fierce. In some states where usable water is in short supply, allocation of water is made largely on an economic basis. In Colorado, water rights are bought and sold in a manner similar to mineral rights. Water rights do not necessarily transfer with ownership of real estate.

Fortunately, water of suitable quality is not in short supply in most areas of the North Platte NRD. The economic value of water is not determined by the highest bidder. The economic value of groundwater could be estimated from the use which is made of it. It follows that good quality water which is suitable for many uses has a greater economic value than poorer quality water which has limited use. Water which is usable for some purpose may have little value for other purposes. For example, water which is high in nitrates has diminished value for domestic purposes, but may be more valuable for irrigation than water with low nitrates.

Poor quality water which has little value in a water rich area may have high economic value in other areas where water is in short supply.

In summary, all water is invaluable, but the economic value of water at any place or time depends on many aspects and can change rapidly depending on general economic conditions in the area where it is used. Ironically, a change in quantity or quality of water supply can also rapidly change the overall economy of an area. The economic value of water is a moving target, which probably can only be accurately measured in dollars if the value is assigned in an open market.

6.0 Identification of Critical Areas for Protection

Figure 12-36 shows areas of potential groundwater contamination in the NPNRD based on the DRASTIC methodology. In determining the vulnerability of the groundwater to contamination, the DRASTIC method takes into account the following parameters: Depth to water, Recharge to the aquifer, Aquifer media, Soil media, Topography (slope), Impact of vadose (unsaturated) zone, and Conductivity (hydraulic) of the aquifer (Reference 149).

On the whole, the NPNRD has not experienced severe problems with the various groundwater reservoirs or principal aquifers described earlier in this document. Recently, however, indications of elevated nitrate - nitrogen content have been found in sampled wells in the Oshkosh area and in individual, dispersed wells in the NRD (refer to Figures 12-22 and 12-23). It is also necessary to note some past problems that have occurred in the Horseshoe Bend, Dry Spotted Tail Creek, Pumpkin Creek Valley, and Harrisburg regions, and to recognize the need to monitor these regions for possible recurrences.

6.1. Oshkosh Area

The North Platte NRD began monitoring domestic wells in the Oshkosh area in 1987. Results of monitoring west of Oshkosh in 1988 and 1989 indicated that samples from a number of wells in that area have nitrate-nitrogen concentrations exceeding 10 ppm. A full report on the results of nitrate sampling in the Oshkosh area is included as Section 3.1.3 of this plan.

6.2. Horseshoe Bend

In the mid to late 1970's, a considerable drop in the water table was experienced in the Horseshoe Bend area south of McGrew that resulted in a lawsuit involving domestic versus agricultural use of the aquifer. Details of this lawsuit are taken from a Memorandum Brief from the County Court of Scotts Bluff County, Nebraska and evidence provided by the Conservation and Survey Division of the University of Nebraska.

The principal aquifer in question was the Chadron Formation, particularly the Chadron Sand deposits in valley fills underlying the Chadron Formation. In this area, the Chadron Sand is a confined aquifer.

The domestic wells involved were drilled to a depth of 510 feet and the artesian pressure forced the water to within 15 feet of the ground surface. Another well was drilled to 620 feet in depth with the subsequent artesian pressure bringing the water to within 70 feet of the ground surface. Submersible pumps were used to deliver the water from the wells for domestic use. These wells were drilled in the 1950's and early 1960's.

In the early 1970's, three wells, to be used for irrigation purposes, were drilled into the same Chadron Sand Formation. The depth of the three wells ranged from 420 to 570 feet below the ground surface and the submersible pumps were set considerably deeper than those in the domestic wells. When the irrigation wells were placed in service, the artesian water level (pressure head) dropped considerably such that the domestic wells could no longer pump water. The explanation for this occurrence is the following: The Chadron Sand in this particular area is approximately 20 to 50 feet thick and the transmissivity, or ability of the formation to transmit water is not great. In order to draw large amounts of water, such as 600 gallons per minute, the drawdown or lowering of the pressure head would be substantial, such as 300 to 400 feet at the well. A pressure head drop of 80 feet was recorded in an observation well two miles from an irrigation well, therefore the cone of depression in the piezometric surface was quite large.

The conclusions were that the source of water, the Chadron Sand, is not being depleted, but the resulting drop in pressure head from pumping large quantities of water will require nearby domestic well pumps to be lowered below the pumping pressure head level in order to obtain sufficient amounts of water. That would also mean an increase in pumping costs for the domestic well users. The courts decided that the irrigator should pay for the costs involved in lowering the submersible pumps for the domestic wells.

It should be noted that subsequent water level monitoring in the Horseshoe Bend area indicates a declining trend in both the pumping level and pressure head level of the aquifer. The NPNRD continues to include this area in their water level monitoring program.

In 1976, the NPNRD requested the Nebraska Department of Water Resources to take the necessary action for the purpose of determining if a groundwater control area should be established in this area in accordance with the Nebraska Groundwater Management Act. Following the necessary public hearings and other appropriate actions, the Department of Water Resources concluded that sufficient evidence was not demonstrated to substantiate the necessity for a control area designation. The main reasons for denying the request were: "The observed decline in the artesian water table represents a reduction in pressure rather than a reduction in quantity; substantial economic hardships are not deemed to now exist, nor are they foreseen as a result of current or reasonably anticipated groundwater withdrawals; dewatering of the aquifer under present or reasonably foreseeable circumstances can be neither verified nor anticipated; based on available technical information, the Chadron confined aquifer behaves in a predicable, classical manner where the pressure head declines as a result of large capacity withdrawal. The 'availability' of the supply has somewhat deteriorated, but the 'adequacy' of the supply remains undiminished."

6.3. Dry Spotted Tail Creek

The Dry Spotted Tail Creek area is located along the southern boundary of Sioux County and northwest Scotts Bluff County in the NPNRD. A localized decline in water table resulted in a lawsuit in the late 1970's and early 1980's. The details of this matter are taken from a Journal Entry from the District Court for Sioux County, Nebraska and are summarized in the following discussion.

Dry Spotted Tail Creek was not a natural stream before the construction and operation of the Interstate Irrigation Canal in 1908 to 1910. Since that time of construction, the major portion of the creek's flow has been during the diversion of water into Interstate Canal, diminishing after the diversion ends in the fall to a negligible amount in the late winter months until about two weeks after diversion into the canal again begins in April. The primary source of water in the creek is from seepage from the canal which causes the water table to rise along the creek and seep into the creek from adjacent springs. The rise in the water table from canal seepage resulted in subirrigation of pasture land and provided a source of water for domestic wells. It was then determined that the ground water in this area was a common aquifer to users in the area. In 1976, a number of irrigation wells were drilled into this aquifer and used for irrigation of agricultural land. Pumping from these irrigation wells caused nearby springs to disappear in the late winter months and the creek to be completely dry during late winter and early spring. The water table was lowered enough by the irrigation pumping to decrease the productivity of subirrigated pasture land and caused some domestic wells in the area to become insufficient.

The Pathfinder Irrigation District has never attempted to recapture seepage water from the canal which affects the groundwater level and the flow of water in the creek.

Conclusions were that the canal is a permanent structure and Dry Spotted Tail Creek is now to be recognized as a natural stream. The plaintiffs were entitled to damages from the defendant (owner of irrigation wells) for new well-drilling expenses, diminution in market value of real estate due to the shortened subirrigation season, and the later start of grazing season because of a lack of usable stream water.

The NPNRD continues to monitor water levels in this area to establish a data base.

6.4. Pumpkin Creek Valley

The principal source of water in the Pumpkin Creek Valley comes from water-bearing fractures in the Brule Formation which was discussed in greater detail earlier in this report. There are some channel-fill deposits of the Chadron Formation underlying this formation that may yield sufficient amounts of water. Only in very small areas do Quaternary deposits, overlying the Brule, contain a zone of saturation thick enough to be a significant source of water supply. These deposits are hydrologically important, however, because they absorb precipitation and transmit it to underlying Brule, in particularly the fractures in the Brule (Reference 93). There has been some concern about declining water levels recorded in irrigation wells tapping the Brule Formation especially noticed after the extensive irrigation development. In concurrence with the irrigation development, it has been claimed by local residents that Pumpkin Creek changed from a perennially flowing creek to an intermittent flowing creek and numerous springs have ceased to flow.

Rights have been granted to divert water from the creek to small reservoirs and canals as well as pumping directly from the creek. As a result of the low flow to no flow of the creek at its mouth at times in July and August, the Nebraska Department of Water Resources has discontinued granting of rights to divert water from Pumpkin Creek.

Due to these occurrences described above, Pumpkin Creek Valley has probably received more public attention than the other isolated problem areas in the NPNRD. The NPNRD has also increased its monitoring of water levels there and cooperated in special studies and evaluations of the water table and flow of water in Pumpkin Creek.

In years of higher precipitation, the water levels recover considerably and that gives some temporary relief to the concerned users of the aquifer.

The character of the Brule Formation continues to be the major problem as attempts are made to accurately evaluate the monitoring data obtained. Consequently, additional research and investigation is currently being done to identify the locations of and depths to known fracture zones in the Brule Formation and better understand the hydraulic characteristics of the formation and its relationship with other water-bearing formations.

6.5. Harrisburg Area

In 1991, the North Platte NRD received a petition signed by most of the residents of the Community of Harrisburg in Banner County, requesting the NRD assume responsibility for the Harrisburg Water System. The NRD board investigated the situation and hired an engineering firm from Scottsbluff to do a study of the current system and to determine what improvements needed to be made to the system to meet current acceptance criteria. It seemed apparent, if the NRD assumed responsibility, that a complete new system, including finding a new water source, would need to be built.

The board ordered a public hearing held on August 13, 1992. The public hearing was well attended with no opposition to the NRD proceeding. The NRD filed a preapplication with the Farmers Home Administration for funding. A favorable response was received from FmHA. However, they would not fund at a level to replace the current system. Then the Banner County Commissioners made an application for a Community Development Block Grant for additional funding. The NRD is not an eligible applicant for block grants so it was worked out with the county commissioners to make the application. That application is currently pending. The NRD is in the process of preparing a final application for funding from FmHA. The NRD has not assumed responsibility for the Harrisburg water system at this time pending the outcome of the grant applications.

7.0 Groundwater Goals and Objectives

As a whole, the entire North Platte River Basin is fortunate to have an abundance of good quality groundwater. It is the intention of the North Platte Natural Resources District Board to maintain this high quality supply for uses by their constituents both now and in the future. For this purpose, the NPNRD has their Groundwater Reservoir Life Goal, which is as follows:

"Maintain an adequate supply of acceptable quality groundwater to forever fulfill the reasonable groundwater demands within the North Platte NRD for domestic, municipal, agricultural, industrial, wildlife habitat and other uses deemed beneficial by the people of the North Platte NRD."

This goal was stated in the 1986 GWMP and is reiterated here as being the major goal of the NPNRD in its groundwater planning efforts. All of the other efforts described here, including the following objectives, the programs and policies presented in Section 8.0, and the groundwater management area implementation plans presented in Section 9.0, are NPNRD plans intended to achieve the Groundwater Reservoir Life Goal.

The following objectives have been established by the NPNRD board to achieve the Groundwater Reservoir Life Goal. Actual programs in support of these objectives are described in Section 8.0. These objectives are also supported by the groundwater management area implementation plans presented in Section 9.0.

7.1. OBJECTIVE 1 - Maintenance and Expansion of Baseline Groundwater Data Gathering Program.

Efforts in support of this objective will include expanding the NRD's monitoring well network, cataloging well logs and gathering geologic data from these logs, sampling wells for water quality, developing and maintaining a computer database and sharing data with other agencies.

7.2. OBJECTIVE 2 - Emphasize Groundwater Conservation Programs in Cooperation with Other Appropriate Agencies.

Programs to support this objective will concentrate on public education concerning best use of irrigation systems and drought management.

7.3. OBJECTIVE 3 - Maintain or Improve Groundwater Quality.

Extensive efforts will be used to pursue this objective including education on Best Management Practices (BMP's), pollution monitoring, investigations into the surface water/groundwater relationship, coordinating programs with other agencies, developing and enforcing regulations, and participation in research programs.

7.4. OBJECTIVE 4 - Promote Research to Gain Adequate Understanding of Current Areas of Concern to Develop Groundwater Management Policies.

Supporting this objective will be research in a number of hydrogeological areas including the alluvial valleys, the Pumpkin Creek Valley, and Chadron Sand areas.

7.5. OBJECTIVE 5 - Understand the Surface Water/Groundwater Interaction in the North Platte Valley.

Programs supporting this objective will include research on the river, tributaries, wetlands and sandhills regions. Also included will be planned investigations into the quantitative and qualitative relationship of groundwater and surface water.

7.6. OBJECTIVE 6 - Explore Integrated Management and Supply Augmentation Measures.

Efforts here will include research into supplemental groundwater supplies for poor quality or quantity areas, cooperative efforts with the town of Harrisburg and the irrigation districts, and the investigation of applying for instream flow rights.

7.7. OBJECTIVE 7 - Develop and Provide Educational Programs to Promote Public Support for and Participation in Management of Groundwater Resources in Cooperation with Appropriate Agencies.

Support for this objective will include the development of a summary brochure on the GWMP, increasing an awareness of groundwater in schoolchildren and adults through public education efforts, promoting proper chemical handling, and supporting legislative efforts to protect groundwater quality and quantity.

7.8. OBJECTIVE 8 - Obtain Funding for Groundwater Management Programs.

When implementation of any of the programs described in the preceding objectives requires funding, a number of alternatives for funding should be considered.

Possible funding alternatives will include grants and/or funding from federal and state governmental agencies, cost share programs, and cooperative studies with interested research groups or agencies.

8.0 Groundwater Programs and Practices

The following programs are established to support the objectives presented in Section 7.0 in order to achieve or maintain the stated Groundwater Reservoir Life Goal for the district. Many of the objectives and programs are attributable to findings from investigation of the hydrogeology of the principal aquifers. It should be understood that full development of all the programs will be dependent on their individual priority and the available economic resources. Unidentified programs and priority ratings may evolve as further understanding of the groundwater system and future development indicates is prudent.

8.1. OBJECTIVE 1 - Maintenance and Expansion of Baseline Groundwater Data Gathering Program.

PROGRAMS

8.1.1. *Expand existing data collection programs to obtain an appropriate distribution of water-level observation wells over the entire NPNRD.*

The existing program in the North Platte NRD consists of monitoring the water level in approximately 143 wells. The 143 wells amount to approximately 7% of the registered wells (approximately 2060) in the district. The network will be expanded to obtain a representative distribution in all the principal aquifers. A large number of public drinking water supply wells are routinely tested by the Nebraska Department of Health (DOH). Reports of this testing will be requested from the DOH and the results used to expand the existing data base. Other problem areas for expanded monitoring are identified in subsequent Objectives and Programs. Levels are currently monitored in the spring and fall each year and this frequency is meeting current needs. Should a significant decline or rise in levels occur, more frequent, selected monitoring may be necessary. Review of the monitoring network is made periodically by the NRD staff in association with USGS and the Conservation and Survey Division of UNL.

8.1.2. *Compile additional geologic data from all future well logs to facilitate more accurate calculation of hydrogeologic properties.*

This will establish a program for the district to obtain well logs and storage of this data for retrieval. This data will be used to make a determination of aquifer thickness, transmissivity and other hydrogeologic properties. In order to accurately plot groundwater characteristics, the additional data that is available will allow more accurate maps to be made. This information will be entered into the computer database for the District.

8.1.3. *Maintain the groundwater quality sampling program and monitor changes in water quality.*

The existing water quality monitoring network is sampled every 2-5 years. The exact sampling interval will depend on aquifer vulnerability to contamination as determined by the expectations of potential groundwater pollution for the area. This process will help provide the NPNRD with the information needed to project long term trends in water quality for the district.

The NRD expects to rely heavily upon the results of sampling of public water supply wells by the Nebraska DOH to determine trends in water quality.

The number of wells and areas sampled may change over the life of the program as new information becomes available. The expectations of areas of contamination will influence the location and number of monitoring wells used by the NPNRD. The data gathered by the district will also determine how monitoring wells are selected and sampled.

8.1.4. *Develop and maintain an NRD computer database for existing and future groundwater information and analysis that is compatible with state and federal systems, in so far as is possible.*

This program involves maintenance of computer systems sufficient for NRD needs. A computer has been purchased, set up, and supplied with software and hardware capable of management, analysis, and report generation of the data collected within the NRD. Emphasis will be placed on compatibility with existing systems of other governmental agencies. The implementation of a Geographic Information System for data analysis and management will be a goal for the North Platte NRD. This type of system is being utilized by government agencies from federal level down to local governments. This type of system will provide the greatest benefit for supplying the NRD with information management and analysis needed for making decisions on resource management issues.

Data from this system will be used to generate reports, maps and graphics on groundwater quantity and quality throughout the district. This information will be used by the district board of directors and staff for policy development and implementation.

8.1.5. *Improve efficiency and accuracy by replacing outdated data gathering equipment with newer state-of-the-art instrumentation, as feasible.*

This program will include replacing existing analog automatic recorders in monitoring wells with modern digital equipment. This program is expected to progress slowly, only as budgeted funds are available, as this instrumentation is fairly expensive.

8.1.6. *Identify with other agencies the groundwater data collection taking place and share data to prevent duplication.*

There are several agencies which currently collect groundwater data. The primary agencies are the US Geological Survey, University of Nebraska Conservation and Survey Division, US Fish and Wildlife Service, Nebraska Department of Health, Nebraska Department of Environmental Quality and the NRD's. These agencies all have programs to meet different needs and the district will cooperate with each to prevent duplication of efforts.

8.1.7. *The state wide test hole drilling program should be continued for the NPNRD by CSD and the state.*

The test hole drilling program provides the most accurate and comprehensive geologic data available for groundwater work. Additional test hole drilling is needed in the NRD. Information on the complexities of the subsurface geology of an area is vital when any type of hydrogeological work is attempted. The decisions on managing the groundwater of the NPNRD will be improved if this type of information is provided.

As the demands for surface and groundwater resources grow, data on the interrelationship of these resources will have to be known. This type of data includes accurate subsurface geologic information. The types of models that will be developed in the future for these resources will be more accurate in their predictions if this information is available.

Installation of dedicated monitoring wells will be incorporated into this program as feasible. Dedicated monitoring wells provide information on groundwater quality and quantity that is not influenced by wells that are used for other purposes.

8.2. OBJECTIVE 2 - Emphasize Groundwater Conservation Programs in Cooperation with other Appropriate Agencies.

PROGRAMS

8.2.1. *Improve management of municipal, industrial, and irrigation systems through public education and research programs to protect both quantity and quality of groundwater.*

8.2.2. *Steps will be taken to disseminate current information pertaining to water use and to encourage water use efficiency. Best Management Practices will be emphasized by this program and will be targeted to all types of water use in the district.*

Carefully planned irrigation scheduling will be encouraged to maximize water use efficiency by supplying the correct amount of water to crops at critical growth periods. If properly conducted, irrigation scheduling can also minimize potential runoff and the possibility of deep percolation. The discharge of tailwater will be minimized during and immediately after the application of agricultural chemicals to prevent pollutants from being discharged into receiving waters. These same chemicals are most often transported as compounds attached to erosional sediment in irrigation runoff.

Tailwater management systems will include reuse pits, drains at the lower end of the field for possible reuse on downstream fields, grass strips at the end of the field and sediment basins used to temporarily slow the runoff water and allow settling of the sediment. Improved water management by industrial, municipal and other users will be included in any information and education programs.

Cost-share is available for the installation of flow meters, surge valves and tailwater recovery systems under current programs. The district will encourage cooperators to adopt these practices.

8.2.3. *Develop and maintain a drought management and education program in cooperation with appropriate state and federal agencies.*

Nineteen ninety-two Legislation established the "Climate Assessment Response Committee" which was created to facilitate smooth operation of existing drought response programs available through various agencies.

Geological Survey Water Supply Paper 1804 "Drought of the 1950's With Special Reference to the Mid-Continent" (Reference 106) is of great value to NRD's and other agencies concerned with drought. A flood is a specific event that can be seen and measured. A drought, on the other had, is less an event than a situation and is difficult to describe as a course of specific events because commonly there is little measurable change from month to month. Drought occurs when the water available to plants is less than required for optimum growth and development.

Drought severity was formerly evaluated largely on the basis of damage to crops and other vegetation, to livestock and wildlife, and to the soil cover. Nowadays, however, municipal and industrial demands for water are so heavy and widespread, including demands in drought prone areas, that drought effects all normal activities.

8.3. **OBJECTIVE 3 - Maintain or Improve Groundwater Quality.**

<u>PROGRAMS</u>

8.3.1. *Encourage, through informational and educational programs, best management practices (BMP) for use of crop nutrients and pesticides necessary for crop production to protect or improve groundwater quality while maintaining optimum levels of crop production.*

This program will involve the agricultural and urban communities in a program to help protect groundwater quality. There are practices which have been used in the past that have not adequately considered the impact on groundwater quality. This is true of urban dwellers as well as farmers and ranchers. In town, lawn and garden chemical applications are often poorly managed and need improvement. Many studies have linked the presence of nitrates to fertilizer applications. Pesticides have also been detected in groundwater. There are many things that can be done to reduce the potential for problems with fertilizer and pesticide application. Control of surface water runoff from wastewater treatment lagoons, both urban and livestock, will be encouraged so as to avoid groundwater degradation.

The BMP for agricultural and lawn chemicals involves the most efficient use of chemicals in the production of crops or the growing of grass. This will mean proper timing of applications and conservation so as not to over apply. This practice will reduce the impacts of lawn, garden and agricultural chemicals on groundwater but will not eliminate contamination.

Another practice will be utilizing adequate pollution control equipment to prevent spillage of chemicals. Examples include controls and check valves on chemigation equipment. This program will be diligently enforced.

Additional testing of soils to determine the presence of nitrates and pesticides below the root zone will identify problem areas.

The application of best management practices will be encouraged on a voluntary basis and strongly urged where problem areas exist. BMP's will be required under certain levels of a groundwater management area (See Section 9.0).

It has been shown in some studies in Nebraska that the level of nitrates in groundwater can be reduced by taking advantage of the nitrates in the water when irrigating crops. This practice could help improve groundwater quality without adverse impact on crop production.

The actual recommendations for any area will be based on its location, soil structure and the type of crop raised. In order to make application recommendations, the University of Nebraska Extension Service will be utilized. The county Extension Agent can provide much of the information both farmers and city dwellers can use for application. Part of this program will be an extensive education program to improve the practices that are now used. This will make people more aware of the impact their actions will have on groundwater quality. As a part of the educational programs, media coverage would help heighten awareness.

All of the above can and will be implemented. Coordination with chemical dealers, applicators, Extension Service, and other education institutions will be initiated when these programs are implemented to assure all necessary measures are taken.

8.3.2. *Monitor Agricultural/Industrial/Municipal Chemical Pollution*

This program will involve the sampling of groundwater for Agricultural/Industrial/ Municipal pollutants on a regular basis to determine whether a problem exists. As part of the baseline sampling program, pesticide parameters will also be monitored.

Areas of high contamination potential will be reviewed by study or on a onetime sampling to determine if a problem exists. Only if the presence of a pollutant exists would more extensive monitoring occur.

Where chemigation is occurring, the presence of pesticides and fertilizers in the water will also be monitored to determine the effectiveness of pollution control equipment. This could possibly involve a water test program for these applicators. Samples will be taken from a representative sample of affected wells.

The results of this monitoring will be used in the education programs to help inform people of problem areas they may be contributing to and how to correct such problems.

8.3.3. *Establish baseline data to determine what the relationship is between the quality of surface irrigation water and the quality of groundwater underlying the area.*

This program requires a joint venture between the NRD, surface water irrigators or irrigation companies and other agencies to avoid a misunderstanding of the intent. There is an active interaction between surface irrigation water and groundwater, therefore, water quality aspects will be considered. (A summary of the NPNRD water sampling procedures is given in Section 3.1.2).

8.3.3.1. Provisions will be made for sampling surface water at strategic locations in streams and drains that carry irrigation return flow. Sampling times and methods will be critical to providing accurate data, therefore all studies must be carefully planned. Results will establish quality characteristics related to groundwater/surface water interactions.

8.3.3.2. Sampling locations will include wells that are located in close proximity to irrigation canals or tailwater canals.

8.3.3.3. The highly permeable soils in the irrigated areas allow a fairly large amount of water to percolate down to groundwater which eventually returns to the river and is again diverted from the river for irrigation. This cycle may occur numerous times between the upstream areas in Wyoming and the NPNRD. Research will be encouraged to determine if the recycling of water has any effect on the groundwater quality in the NPNRD.

8.3.4. *Encourage comprehensive enforcement of the existing rules and regulations of the Nebraska Oil and Gas Commission regarding exploration and oil well abandonment.*

Rules and regulations for oil and gas exploration do exist. However, there has been concern among local residents that the current level of enforcement may be inadequate. The level of communications between the NRD and the Nebraska Oil and Gas Commission will be increased so that specific problem areas encountered in the NRD will be passed on to the Oil and Gas Commission for their information and further action.

8.3.5. *Coordinate NRD programs with the appropriate state, federal and local agencies to effectively promote proper siting, management and construction of such facilities as* *public water systems, municipal water disposal systems, urban runoff and drainage systems, feedlot drainage, sanitary landfills and agricultural land drainage systems.*

The NPNRD will encourage and cooperate with the monitoring of the facilities mentioned above. These could be sources of contamination if they are not properly designed or managed. Many agencies are involved in pollution monitoring. The primary agency for this program is the Department of Environmental Quality. Another key agency is the University of Nebraska through the Extension Service and the Conservation and Survey Division. The State Health Department also has a role in the area.

Federal agencies are the ASCS, the USGS and the EPA. An effective program of coordination will need to be implemented to assure all these agencies are providing the feedback to the NRD necessary to properly manage groundwater quality. This may require additional communication with these agencies to assure that everyone is working in the same direction. Where these agencies identify a problem, the information and data will be requested by the NRD to assure proper management and policy decisions are made. One way to promote this coordination is to have a representative of these agencies working closely with the NRD on a regular basis.

8.3.6. *Work with DEQ to promote coordination with NRD groundwater protection strategies.*

This program will propose a close coordination and association with the Department of Environmental Quality to assure that State and Federal groundwater programs are not being duplicated and that the NRD maintains proper controls to manage the groundwater resources in the area.

8.3.7. *Cooperate with the appropriate state agencies in developing and enforcing adequate regulations for uranium mining or other potential mineral exploration and mining.*

The potential exists in the NPNRD for in-situ uranium mining which involves the use of groundwater. Class I-IV injection wells are normally associated with this type of operation and are regulated by other agencies.

8.3.8. *Identify, in cooperation with appropriate agencies, radioactive contamination potential.*

This program could be related to Program 8.3.7 above, however, the potential for radioactive contamination may not be directly related to any mineral mining. Findings of the National Uranium Resource Evaluation Program (NURE) will be carefully analyzed for implications for further studies. There are results from water samples taken during the USGS Groundwater Study in 1991 that indicate a problem exists with radon and uranium in the NPNRD.

8.3.9. *Work with the appropriate agencies to determine the impact of injection wells on groundwater quality.*

This program will look at several types of wells not currently regulated and determine if controls or programs for their proper implementation should be established. This will cover wells known as Class V injection wells. Class I-IV wells are normally associated with oil or mineral production or hazardous and radioactive waste disposal and are regulated by other agencies. Class V wells include agricultural drainage wells, cooling water return flow wells, groundwater recharge wells, septic tanks for multi-family systems, and groundwater heat pump wells (open loop).

The Nebraska Department of Environmental Quality has done extensive research in Class V injection wells and this work will be coordinated with the NRD program as part of Program 8.3.6 above. This is important especially if DEQ is planning on establishing a permit program.

8.3.10. *Work with the appropriate agencies to conduct research on the extent and nature of naturally occurring contaminants.*

Information on naturally occurring contaminants will be required before the NRD can adopt any management policies for these problems. Research into distribution, contamination levels, relation to geology and land use, etc., will be encouraged.

8.3.11. *Encourage use of the NPNRD Water Well Abandonment Program through news releases and promotional brochures.*

This program is designed to promote proper abandonment of unused water wells. Unused water wells can contaminate groundwater supplies by providing a direct conduit from the surface to groundwater.

As an incentive to properly abandon water wells, the North Platte NRD will provide funds upon application and approval to any individual landowner (excluding publicly owned or industrial wells) within the NRD, provided certain criteria are met. The Board of Directors will consider applications each year for individual grants from the fund, up to the budgeted amount. The maximum contribution by the NRD will be 65% of actual cost, not to exceed $100.00 for a small diameter well (less than 6"), $250.00 for medium diameter well (6" up to 12") and $400.00 for a large diameter well (12" or greater). The NRD will provide funds only for abandonment and not for removal of any equipment or structures on or in the well. All work must be performed by a Nebraska licensed well driller according to the State of Nebraska Department of Health regulation guidelines. The well driller must certify completion of the work according to Nebraska Department of Health regulations.

To be eligible to receive funds a landowner must apply on forms provided by the NRD showing the amount of funds requested, and furnish evidence on the following items:

1) Exact location of water well to be abandoned.

2) Construction of water well: depth, type of casing, diameter of casing.
3) Name of Nebraska licensed well driller who will perform work.
4) Cost estimate from well driller.
5) Estimate of when work will be completed. Work must be completed within 6 months of application approval.

Funding will be available on a first come first served basis and will continue until budgeted funds are depleted.

The NRD may inspect work to check compliance with the guidelines of the program. Upon completion of work, a form describing the abandonment must be received by the NRD from the well driller.

Payment will be made to the landowner following successful completion of the work and on approval of the manager.

This Policy Statement was approved by the Board of Directors at an official Board Meeting held at Bridgeport, Nebraska on May 14, 1992.

8.3.12. *Work with other agencies to determine the number of active and abandoned registered and unregistered irrigation wells in the NPNRD.*

Future modeling of the NPNRD will require an accurate estimate of these wells. The NPNRD will encourage all wells that are drilled in the future be registered properly and that notice of abandonment of said wells be sent to DWR. Registration of all water wells is now required by law.

8.3.13. *Work with communities to encourage participation in the Nebraska Wellhead Protection Program.*

The Nebraska Wellhead Protection Program was initiated by the Nebraska Department of Environmental Quality to protect the wellhead areas of public water supplies from contaminants which may have any adverse effect on the health of persons.

Wellhead areas are the water-saturated subterranean strata from which groundwater is withdrawn for public supplies, along with the overlying unsaturated subterranean strata, land surface, surface waters, and air space providing groundwater recharge to such strata.

Public water supplies are community and non-community supplies regularly used by 25 or more persons, or delivering water through 15 or more service connections.

Wellhead Protection Areas (WHPA's) are those parts of wellhead areas from which groundwater contaminants could be expected to reach a public water supply well within the useful lifetime of that well. (For purposes of Nebraska's WHP program, 20 years has been chosen as the useful lifetime of a public water supply well).

At the present time there is no comprehensive legal authority to mandate wellhead protection, however, DEQ is promoting participation on a voluntary basis. As part of its efforts to maintain high quality groundwater for its residents, the NRD will also encourage communities to adapt Wellhead Protection measures. The active role of the NRD in the program will include educating the public about Wellhead Protection, supporting groundwater quality monitoring within WHPA's, and developing groundwater management area programs which complement wellhead protection.

8.4. OBJECTIVE 4 - Promote Research to Gain Adequate Understanding of Current Areas of Concern to Develop Groundwater Management Policies.

PROGRAMS

8.4.1. *Research contaminant potential for the alluvial valleys in the NPNRD to further refine the areas delineated in the state DRASTIC map.*

8.4.2. *Encourage research in the Pumpkin Creek Valley.*

8.4.2.1. Research the vertical and horizontal extent of the fractures in the Brule Formation to gain a better understanding of where they exist, their areal extent, specific aquifer properties, and their hydraulic interactions with unfractured Brule.

8.4.2.2. Determine how water levels fluctuate above the Brule fracture zone with different intensities of water use (such as with different irrigation systems for different crops).

8.4.2.3. Interpret surface water/groundwater interactions with various water demands.

8.4.3. *Encourage research on the Chadron Sand to better understand this aquifer system in the NRD.*

8.4.3.1. Expand the current monitoring program to include quality parameters and to determine what effects, if any, might be seen on land surfaces from using irrigation water from the Chadron Sand. Include head measurements in Chadron wells elsewhere in the NPNRD.

8.4.3.2. Monitor the current groundwater use, i.e., domestic, agricultural, industrial, etc.

8.4.3.3. Gain an understanding of the hydraulics and hydrogeologic parameters of the Chadron Sand in the area.

8.4.3.4. Conduct a survey of current wells using the Chadron Sand Formation to determine the extent of its use.

8.4.3.5. Investigate methods of artificial recharge to the Chadron Sand aquifer.

8.5. OBJECTIVE 5 - Understand the Surface Water/Groundwater Interaction in the North Platte Valley.

PROGRAMS

8.5.1. *Continue research to identify the surface water/groundwater interaction in the North Platte Valley for both quality and quantity.*

Previous studies have acknowledged the interaction but additional research is needed to determine a quantitative relationship. Our current understanding is that the existence of the surface irrigation system in the North Platte Valley provides substantial recharge to the underlying aquifer and that such a relationship should be maintained. (Refer to Figure 12-35 for the surface irrigation system boundaries.) Ongoing studies, such as groundwater level measurements, the University Lake groundwater/surface water study, and groundwater/surface water quality studies, will provide the needed information to enhance any management decisions or best management practices. These are the type of framework studies needed to provide information on existing systems for modeling purposes.

8.5.2. *The Sandhills surface water and groundwater will require future investigation.*

The Sandhills is a unique area that is not homogenous. The diversity of the geology and water resources contributes to its complexity. The Sandhills region seems to be unaffected by present groundwater and surface water uses. Impacts from changing these uses have to be considered before they are implemented.

8.5.2.1. Information from studies of groundwater and surface water quantities in the Sandhills will be useful in long term management planning. Any large development of Sandhills water supplies could have major negative impacts to the area and to areas surrounding the Sandhills that rely on ground/surface water discharge from there. Detailed studies of the geology and hydrology of the Sandhills will provide guidance for policy decisions.

8.5.2.2. Information from studies of Sandhills water quality will provide background information and provide guidance in policy decisions. The Sandhills has some of the best and worst water quality in the NPNRD. An investigation into why these diverse conditions occur and whether they will change over time would help in management planning. Impacts of different land uses on water quality need to be determined in order to protect the resource. Development of this area may impair water quality.

8.6. OBJECTIVE 6 - Explore Integrated Management and Supply Augmentation Measures.

In the Policy Issue Study on Integrated Management of Surface Water and Groundwater it is noted that the terms "integrated management" and "conjunctive use" are sometimes used interchangeably. "Integrated management" of surface water and groundwater refers to any combination of physical, technical, administrative and legal practices applied to surface water and groundwater in a manner designed to increase combined benefits or to achieve a more equitable apportionment of benefits from both sources. This implies a planned system of use whereas "conjunctive use" may occur without such a planned system.

Supply augmentation is considered to be the direct use of water from an outside source to augment an existing supply of water to make up for insufficient quantity or for the addition of new uses.

PROGRAMS

15.

8.6.1. *Re-evaluate existing reports and initiate feasibility studies for providing supplemental groundwater supplies to municipalities, industries, and rural water users of the basin where deficiencies exist in quantity and quality required for beneficial uses.*

The NRD will cooperate with public water suppliers in locating additional water for their use where feasible.

It has been established that the existing surface water irrigation system of the North Platte Valley is vitally important to the area's economy as well as the most prominent source of groundwater recharge.

Other integrated management concepts include the use of detention reservoirs for storage of excess instream flow or tailwaters from irrigation systems or direct injection wells for recharge.

Specific problem areas have been identified in Section 6.0 of this report.

8.6.2. *Investigate additional water supplies and revamping of distribution system for the Harrisburg community.*

8.6.3. *Provide information to Irrigation Districts to assist in adjudications and applications for incidental underground recharge.*

8.6.4. *Investigate the desirability of making application for instream flow rights to protect and enhance critical riparian and wetlands habitat.*

8.7. **OBJECTIVE 7 - Develop and Provide Educational Programs to Promote Public Support for and Participation in Management of Groundwater Resources in Cooperation with Appropriate Agencies.**

<u>PROGRAMS</u>

8.7.1. *Develop a Summary Brochure of the NRD Groundwater Management Plan.*

The NRD staff will prepare and publish a brief Groundwater Management Plan brochure which can be widely distributed to the public.

8.7.2. *Develop an awareness of the value of groundwater in school age children.*

8.7.2.1. The NRD staff will continue to provide a youth-oriented groundwater awareness curriculum which can be presented by NRD staff members at school assemblies, county conservation days, 4-H meetings, scout meetings, county fairs, festivals, etc., throughout the district.

8.7.2.2. The presentations will include distribution and discussion of the groundwater management plan brochure; visual illustrations such as slides or videos; and demonstrations of basic groundwater hydrology principles such as how groundwater is withdrawn through a well, how precipitation and surface water percolate to the groundwater table, and how pollutants can be introduced into groundwater.

8.7.2.3. The presentations will clearly illustrate the multitude of direct and indirect uses and needs for groundwater which a typical citizen relies on each day.

8.7.2.4. Continue to cooperate with and promote the Water Wonders Program for school children.

8.7.3. *Expand adult citizen awareness of the value of groundwater.*

8.7.3.1. The NRD staff will develop groundwater awareness programs appropriate for presentation to adult organizations such as church groups, fraternal clubs, business societies, county fairs, festivals, etc.

8.7.3.2. Groundwater information will be presented in NRD promotions such as brochures, newsletters and other publications.

8.7.4. *Provide technical information in cooperation with the appropriate organizations or agencies to assist groundwater uses.*

8.7.4.1. Rely on the University to provide crop water use and irrigation scheduling data to farmers.

8.7.4.2. Rely on the University to assist farmers in determining fertilizer requirements based upon nitrate concentrations in irrigation water and in the soil.

8.7.4.3. Cooperate with the University of Nebraska Cooperative Extension Service to organize and present annual continuing educational programs on best management practices for farmers.

8.7.4.4. Cooperate with local agencies to organize and present annual continuing educational programs on best management practices for municipal water system operators and users.

8.7.4.5. Encourage domestic well owners to monitor the quality of their groundwater supply.

8.7.4.6. Establish a permit process for the construction of new wells to facilitate an opportunity for NRD review and distribution of educational material prior to construction of any new well in the NRD.

8.7.5. *Support reasonable new legislation to obtain NRD jurisdiction of wells having less than 100 gpm capacity.*

Such jurisdiction would allow the NRD to review construction details of small capacity wells and subsequent quality sampling. A well log should be required from the well driller for all wells constructed.

8.7.6. *Promote proper chemical handling especially around wellheads and areas of recharge to groundwater.*

8.7.7. *Provide information and education for public awareness of management areas and regulations.*

8.7.8. *Support legislation to protect and enhance water quality.*

8.8. **OBJECTIVE 8 - Obtain Funding for Groundwater Management Programs. When implementation of any of the programs described in the preceding objectives requires funding, the following alternatives for funding should be considered**.

<u>PROGRAMS</u>

8.8.1. *Seek Funding from the State of Nebraska for groundwater management purposes.*

8.8.1.1. Work for legislation to provide, as a minimum, state matching funds for NRD administered groundwater management programs. The only groundwater program mandated by statute is this plan. Everything else is enabling legislation.

8.8.1.2. Pursue funding from state agencies for data collection programs for which there is common interest.

8.8.2. *Seek Funding from other governmental agencies.*

8.8.2.1. Monitor federal programs for funding opportunities and file applications for funding if appropriate.

8.8.2.2. Pursue cost-share funding from federal agencies for data collection programs for which there is common interest.

8.8.2.3. Consider inter-agency agreements with local governmental subdivisions for studies, data collection, and service programs for which there is common interest.

9.0 Groundwater Management Area Implementation

It is the intention of the NPNRD Board of Directors to establish the entire NRD as a Groundwater Management Area (GWMA), under the provisions of the Nebraska Groundwater Management and Protection Act. This action is being taken to provide the NRD a tool with which to control groundwater depletion and/or contamination in pursuit of the Groundwater Reservoir Life Goal.

9.1. Legal Background

The State of Nebraska passed the Groundwater Management Act in 1975, in response to the growing concern over the depletion of the groundwater through mining of the aquifers occurring in the state. This act provided the means by which groundwater depletion could be controlled and regulated. The original Act did not address groundwater quality issues.

In 1982, the Nebraska state legislature revised the Groundwater Management Act to allow creation of groundwater management areas, but the focus of the Act was still on water quantity. The title of the Act was changed to the Groundwater Management and Protection Act (GWMPA). A 1984 revision to this Act called for each of the twenty-three NRDs to develop a groundwater management plan, which would inventory the groundwater resources within each district. Further revisions, included in the 1986 update of the Act, defined the role of the Natural Resources Districts and provided the means by which they could address non-point source groundwater contamination. Even more emphasis was placed on water quality when, in 1991, legislation was passed that required revision of the groundwater management plans to address water quality concerns in detail.

With these revisions, the state has given primary responsibility to the NRDs for administering non-point source regulations through the ability to implement Groundwater Management Areas (GWMA's).

For a more complete summary of groundwater management legislation see Appendix 11.1.

9.2. Groundwater Management Areas

In the area of groundwater quality issues, the NRDs are the primary entity responsible for non-point source contamination concerns. Through the Groundwater Management and Protection Act (GWMPA), there are two options available for dealing with non-point source groundwater contamination: 1) The establishment of Special Protection Areas (SPA's) by DEQ and (2) The establishment of Groundwater Management Areas (GWMA's) by the NRD. Special Protection Areas can be established by DEQ after a study, hearing and determination that non-point source contamination is occurring within a definable area. The NRD must then prepare an "action plan" designed to stabilize or reduce the level and prevent the increase or spread of groundwater contamination. The action plan must be approved by DEQ. DEQ will adopt and enforce protective measures in an SPA if the local NRD does not. A Management Area may be established by the local NRD after preparation of a groundwater management plan and a public hearing conducted by the NRD. While the plan must be reviewed by state agencies, it can be implemented even without their approval. A pre-existing problem with groundwater quantity or quality is not required to establish a GWMA. The purpose of a GWMA is to protect groundwater quantity and/or quality.

Through the GWMPA there are also two options available for dealing with groundwater quantity problems. The first option, available to NRD's, is the establishment of a GWMA as discussed above. The second option is the establishment of a Control Area (CA). Control areas involve actions by DWR after a hearing requested by the NRD, and are established mainly for groundwater quantity protection in areas where there is an inadequate supply of groundwater for present and reasonably foreseeable use.

The NPNRD strategy for the protection of groundwater quality stresses prevention of groundwater contamination, recognizing that it is much more expensive to clean-up a problem than it is to prevent one. SPA's are somewhat reactive in nature, in that contamination must be occurring or be likely to occur before the program goes into effect. A management area, on the other hand, can be more proactive -- actions can be taken to prevent a problem before it occurs and even before there is hard evidence that it is likely to occur. In addition, under a GWMA, control remains under the exclusive jurisdiction of a more localized government entity (the NRD), which is in close touch with the people who are affected by the controls and the effects of any groundwater contamination. For these reasons, the NPNRD has chosen to establish the entire NRD area as a Groundwater Management Area in direct support of the Groundwater Reservoir Life Goal.

To date, groundwater management areas have been established in the Central Platte, South Platte, and Tri-Basin NRDs and are in the process of being formed in the Upper Elkhorn and Lower Loup NRDs.

9.2.1. <u>Consequences of GWMA Formation</u>

The NRD Board of Directors may establish a GWMA after approving a Groundwater Management Plan (GWMP), obtaining the approval of that plan by DWR (or explaining why the NRD does not concur with DWR objections), and holding a public hearing on creating the GWMA. Once a GWMA is established, the following actions by the NRD are required or permitted, as noted:

1. Permits from the NPNRD are immediately required for all water wells.

2. The NPNRD must adopt one or more of the authorized controls listed below (those must be in the adopted groundwater management plan). Authorized controls are:
   a. Develop educational programs to protect water quality.
   b. Allocate water on an acre-inch basis.
   c. Adopt a system of irrigation rotation.
   d. Require uniform percentage reduction of irrigated acres.
   e. Adopt well-spacing requirements (more limited authority than in Control Areas).
   f. Require water meters.
   g. Require "best management practices" (irrigation scheduling, timing of fertilizer and pesticide application, and other fertilizer and pesticide management programs).

h. Require analysis of water or deep soils for fertilizer and chemical content.

The controls adopted will depend on the level of severity of an existing problem. As severity increases, reaching established "triggering" levels can place the area into a higher level of controls. (The NPNRD's system of levels, triggering mechanisms, and applied controls are discussed in Section 9.4.)

3. The NPNRD must determine the total amount of water to be withdrawn from the aquifer consistent with the ground water reservoir life goal and must adopt controls to allow the beneficial use of that amount of water. The NRD must take these actions even if the GWMA was established for water quality purposes.

4. The NRD may levy tax up to 1.8 cents per $100 valuation in the management area.

9.2.1.1. Enforcement of Controls

In a GWMA, the primary enforcement tool is the issuance of cease and desist orders and suits against alleged violators who fail to abide by cease and desist orders. Violation of cease and desist orders is a Class IV misdemeanor. In addition, the district may bring an action in District Court to obtain a court order to enforce the cease and desist order. Failure to follow a court order subjects an individual to contempt of court proceedings.

9.3. Establishment of Sub-Areas in the NPNRD

Upon establishment of a GWMA, the entire NPNRD will be under Level I Quality and Quantity controls (see Section 9.4). Particular problem areas in the NPNRD have specific needs because of varying groundwater uses, different irrigation distribution systems, different crop types, or varying climatic, hydrologic, geologic, or soil conditions that exist within the North Platte NRD. Thus, uniform application of controls throughout the district would fail to carry out the intention of this plan. It is therefore necessary to provide flexibility for any higher levels of management listed in this plan.

It is the intention of the NPNRD to establish groundwater management sub-areas, as needed, in specific areas of the NRD with actual or potential problems of groundwater quality or quantity. As the need arises, the NPNRD Board of Directors will delineate and establish these sub-areas in regions where the potential for groundwater quantity or quality problems exists or where actual problems have been identified. The procedure the NPNRD will follow in determining when and where sub-areas are required is as follows:

The NRD will review the results of their groundwater monitoring program at least annually (see Section 10.2). When the data show that the triggering levels for either Quality or Quantity (which are presented in Section 9.4.1.2 and 9.4.2.2, respectively) have been reached or exceeded, the NRD will take the following actions:

1) Conduct further studies (review existing data and gather additional data, if necessary) to determine the extent and seriousness of the problem or potential problem. If it is determined that no problem or potential problem actually exists, then no further action is required.
2) Set the boundaries of the proposed sub-area within which the problem is occurring. The boundaries will be legally definable (following township or section or quarter-section lines, roadways, rivers, etc.).
3) Decide on the controls which will be applied in that sub-area in order to address the problem. (Some possible controls for quality and quantity problems are suggested in sections 9.4.1.2 and 9.4.2.2, respectively.)
4) Set new triggering levels which will trigger further action by the NRD (including a next level of stricter controls) if the currently enacted controls do not alleviate the problem.
5) Hold a public hearing at which this information is presented to local residents of the proposed sub-area.
6) Formally amend the Groundwater Management Plan to establish the sub-area and enact the controls. A written amendment to the plan will be published and attached to the plan.
7) Submit the amended plan to DWR for review by state agencies and approval by DWR.

It is expected that the above process will be completed within one year of the time the problem is first identified and brought to the NRD Board's attention. By statute, however, the Groundwater Management Plan can be formally amended no more than once a year. Therefore, this may delay the above process in some circumstances.

The purpose of establishing sub-areas is so that different controls and/or levels of controls may be applied over a specific area of the NRD as required by the conditions in that area, without having to apply those controls or levels over the entire NPNRD. The authority for different controls is Nebraska State Statute 46-666(4). The relevant bases for applying different controls is varying climatic, hydrologic, geologic, or soil conditions. The NRD Board will use these bases when determining boundaries for sub-areas. As an example, an area with high nitrate concentrations in the groundwater would have different hydrologic conditions than surrounding areas without high nitrate concentrations. After establishment, individual sub-areas have the same legal status as an individual management area would have.

The district also recognizes that hydrologic, geologic, land use, recharge, and water quality conditions differ markedly throughout the district. Because of this variability, the district anticipates that special regulation of development and use may vary, and that in order to establish a rationale for regulations, the intensity and frequency of data collection will vary area by area. To this end, the NPNRD has prepared a map and has preliminarily established boundaries for nine separate areas within which climate, hydro-geologic, or soil conditions are unique (Figure 12-37). The establishment of sub-areas may be based on this map. The district expects that the boundaries will be modified as needs and problems become more clearly focused.

9.4. Implementation of Controls in Management Areas and Sub-Areas

In every established management area and sub-area the level of controls applied will depend on the severity of the problems identified in that area. Every area begins with Level I quality and quantity controls. As certain "triggering levels" are reached in an area, as determined from the results of the NPNRD's monitoring well sampling program, then additional levels of controls are applied in that area or sub-area after action by the NRD Board (See Section 9.3). Triggering levels may be defined as a percentage of the Primary Maximum Contaminant Level (PMCL's) or of the Secondary Maximum Contaminant Level (SMCL's) for quality or as declines in the water table for quantity.

Lists of Maximum Contaminant Levels are issued by DEQ and DOH and are based on lists published by the U.S. Environmental Protection Agency (EPA). Current lists of PMCL's and SMCL's from the EPA Safe Drinking Water Standards are included here in Appendix 11.3. PMCL's are for contaminants which have a proven negative effect on human health when the 100% level is reached. SMCL's are for contaminants which give water a poor taste or color and may be injurious to humans at higher concentrations.

The NPNRD is concerned mainly with man-made contaminants that are a result of non-point source pollution. Typically, this is contamination resulting from agricultural use of fertilizers and pesticides. The quality controls imposed by the NPNRD in a GWMA will be determined by the extent of the problem. The contaminants listed in Table 9.4-1 will be controlled by the NPNRD.

TABLE 9.4-1

MAN-MADE GROUNDWATER CONTAMINANTS MONITORED BY THE NPNRD

Contaminant		MCL	
Inorganic Chemicals:			
Nitrate		10.	mg/l
Nitrite		1.	mg/l
Total nitrate and nitrite		10.	mg/l
Organic Chemicals:			
Pesticides & PCB:			
Alachlor		0.002	mg/l
Aldicarb		0.003	mg/l
Aldicarb sulfoxide		0.004	mg/l
Aldicarb sulfone		0.003	mg/1
Atrazine		0.003	mg/l
Carbofuran		0.04	mg/l
Chlordane		0.002	mg/l
Dibromochloropropane		0.0002	mg/l
2, 4-D		0.07	mg/l
Endrin		0.0002	mg/l
Ethylene dibromide		0.00005	mg/l
Heptachlor		0.0004	mg/l
Heptachlor epoxide		0.0002	mg/l
Lindane	0.0002	mg/l	
Methoxychlor		0.04	mg/l
Pentachlorophenol		0.001	mg/l
Polychlorinated biphenyls		0.0005	mg/l
Toxaphene		0.003	mg/l
2,4,5-TP (Silvex)		0.05	mg/l

The Level I controls listed in Sections 9.4.1.1 and 9.4.2.1 will be applied over the entire NPNRD upon adoption of this plan. Additional or stricter controls may be applied over individual sub-areas as problems are identified and NRD action is initiated by established triggering mechanisms (see Section 9.3). Separate levels of controls are established for quality and quantity problems. Thus, one area or sub-area may have Level III quality controls and Level I quantity controls applied concurrently as required by the specific problems occurring in that area or sub-area.

9.4.1. QUALITY CONTROLS

9.4.1.1. LEVEL I QUALITY

These controls are applicable upon establishment of a groundwater management area over the entire NPNRD. The establishment of a GWMA requires action by the NPNRD Board of Directors.

Controls:

A. Develop and implement an information and education program for the NPNRD. This program will include brochures, newsletters and other methods to encourage the use of Best Management Practices (BMP's) and to inform the public of potential problems. A listing of BMP's from the Soil Conservation Service (SCS) field technical guide is given in Appendix 11.4.

B. Maintain an ongoing program of monitoring wells for groundwater quality, groundwater levels and geological studies of the area. Identify any obvious sources of pollution. Collect land use data for the area. Identify any deficiencies in data.

C. Make sure all existing rules for the prevention of groundwater pollution under NPNRD jurisdiction are enforced (e.g., chemigation). The NRD will cooperate in enforcing the groundwater protection rules and regulations of other agencies as appropriate.

D. Share information with appropriate agencies and seek cooperation in solving problems where applicable.

E. As potential contaminated areas are identified, sampling of additional wells will determine the severity and geographical extent of the contaminated area.

9.4.1.2. HIGHER LEVEL QUALITY CONTROLS

When sampling results show that 75% of MCL has been reached for any constituent in Table 9.4-1 within a mappable area, further action by the NRD is required as per Section 9.3. This action will include determining stricter Level II Quality Controls to be applied to the area and establishing a new triggering level which will initiate further action by the NRD to enact Level III Quality Controls if Level II Controls prove not effective. Higher level Quality Controls which the NRD may choose to enact (depending on the severity of the problem) include, but are not limited to, the following:

A. Increase information and education efforts for the target area.

B. Hydrogeological studies may be conducted to determine movement and travel times of the contaminants. These studies can be done locally or as a joint project with other agencies.

C. Mandatory education and certification of landowner/operators by the NRD may be required.

D. Approved measuring devices for water flow may be made mandatory.

E. Annual reports, which will be tailored to crop and/or contaminant, may be required from landowner/operators and may consist of:

1. Soil sample results and location where samples are taken.
2. Irrigation water sample results from each well.

3. Report on amount of fertilizer/chemical applied to each specific field.
4. Irrigation water used on each specific field.
5. Plans for crops to be grown and planned fertilizer/chemical use for the following year.
6. Flow meter readings from the beginning and end of irrigation season will be reported.
7. Crop yield data will be reported for each field for the year.
8. Estimate of tons of manure applied per field.
9. Crop rotation plan for each field.

F. Best management practices from the SCS Field Technical Guide tailored to the particular problem and area may be required.

G. Deep soil and irrigation water samples may be required.

H. Fall application of commercial fertilizer or chemicals identified as a particular pollutant in the problem area may be prohibited.

I. The NRD may provide one on one assistance to operators (if available).

J. The NRD may apply for federal cost share or some type of cost share for short term incentive programs to encourage producers to adopt BMP's.

K. The NRD may apply for any outside funding for further study on the problem or to provide funding for information and education.

9.4.2. **QUANTITY CONTROLS**

9.4.2.1. **LEVEL I QUANTITY**

17.

A. Provide information and education programs on water conservation and use to water users.

B. Maintain an observation well network for water levels to provide sufficient coverage of all aquifers in the district. At least one monitoring well for each aquifer present per township is the goal.

C. Determine a predevelopment level for each observation well.

D. Land use records shall be gathered for the project area and water uses identified. This will help to determine if land and water use patterns are changing.

E. Share information with appropriate agencies and seek cooperation where applicable.

F. Encourage use of BMP's through educational programs and seminars in cooperation with other agencies.

G. Monitor additional wells to determine the extent and geographical area of suspected areas of groundwater level declines.

9.4.2.2. **HIGHER LEVEL QUANTITY CONTROLS**

The triggering mechanism which will initiate action by the NRD Board to enact higher levels of Quantity Controls per Section 9.3 will be any one or combination of the following:

A. An average water level decline of one foot per year from predevelopment levels due to groundwater withdrawal over a 10-year period.

B. Reports of or evidence of interference between wells.

C. Reports and evidence of impact of groundwater withdrawal upon other water users.

D. Evidence of other problems.

If NRD Board action involves enactment of stricter Level II Quantity Controls, the Board will also establish a new triggering mechanism which will initiate further action to enact stricter Level III Quantity Controls if Level II controls prove ineffective. Higher level Quantity Controls which the NRD may choose to enact (depending on the severity of the problem) include, but are not limited to, the following:

A. Reports may be required from water users on all water used each year. (Wells yielding less than 100 gpm may be exempted).

B. Information and education programs may be increased to include public meetings on the problem.

C. If available, technical assistance to water users may be provided in order to increase efficiency.

D. Funding for cost share for improving water use efficiency may be pursued.

E. A detailed hydrogeological study of the area may be undertaken in order to gather information to make a predictive model for management purposes. This may include installation of recording devices where needed.

F. An inventory of wells in the area may be done to determine number of wells in use.

G. The NRD may increase the number of observation wells in the area, including installation of recording devices.

H. Installation of measuring devices for water flow may be required for water users.

I. Water users may be required to attend training courses and to be certified for water use and measuring device operation by the NRD.

J. Allocation of water use may begin and all users may be required to provide water use records for the year on the first of January the following year. The NPNRD Board of Directors will review allocation schedule and may adjust as deemed appropriate.

K. Well spacing requirements for new wells may become more restrictive.

9.5. Other Actions

None of the above precludes the NPNRD Board of Directors from requesting the State of Nebraska for designation of a Special Protection Area or Control Area.

9.6. Relaxation of Controls

If the results of the NPNRD's monitoring well sampling program for an area indicate that a triggering level for a level of controls lower than that level which is currently being enforced in that area is met for three consecutive years, then controls in that area will decrease to that level, unless specific action by the NPNRD Board maintains the current level.

Example: An established sub-area is currently under Level II quality controls due to nitrate readings in monitoring wells of over 75% of MCL. If nitrate level readings in monitoring wells in that sub-area are below 75% of MCL for three consecutive years (and no other Level II triggering levels are met for other contaminants), then that sub-area will revert to

Level I quality controls after the third year, unless the NPNRD Board determines a problem still exists and acts to maintain Level II quality controls in that sub-area.

This relaxation of controls is an acknowledgement that the problem which had existed in that area has been remediated and that the lessons and practices learned during the remediation process, employed by the residents of that area, will continue to maintain an improved water quality or quantity without the burdens and restrictions imposed by a higher level of controls.

If, however, in any subsequent year, in an area in which controls have previously been relaxed, a higher triggering level for the same contaminant is reached, the controls in that area will be re-instated at that higher level and will remain there until the following three conditions are all met:

1) A minimum of ten years have passed;
2) The contaminant level in the area has dropped to a lower triggering level and remained there for at least five subsequent years; and
3) The NPNRD Board of Directors acts to remove the higher level controls and reinstate a lower level of controls as appropriate for the existing triggering level.

Example: Four years after the controls in the area in the example above were relaxed to Level I quality, well sampling in that area indicates nitrate readings over 75% of MCL. The controls in that area will immediately revert to Level II quality controls and will remain there until all three conditions mentioned above are met, even if the nitrate readings return to the 75% level or lower, and remain there. This would not require specific action of the NRD Board nor an amendment to the GWMP. (If a different contaminant besides nitrate, should reach Level II triggering levels, the area would also go to Level II quality controls,but would still be eligible for later relaxation of controls for that contaminant.)

This "anti yo-yo" clause acknowledges that it was the presence of the higher level controls themselves that was improving the water quality or quantity in the area and that these controls must remain in place to continue or maintain improvements. Thus, the higher level controls must be reinstated and maintained in that area.

10.0 Plan Evaluation and Assessment

This plan has been written and submitted in fulfillment of the requirements of LB51. As such, it has been reviewed by a number of interested parties

10.1. Preliminary Reviews

Before the final adoption of this plan, it was reviewed by the following entities and modified accordingly.

10.1.1. NPNRD Staff and Board

This document represents the intentions of the North Platte Natural Resources District Board of Directors in regards to the administration of a groundwater management program. As such, the contents herein have been extensively reviewed and discussed by the NPNRD Board and staff members. The plan as presented here reflects the wishes of a consensus of the board members. The plan was approved by the board at a Board of Directors meeting.

10.1.2. State Agencies

A preliminary copy of this plan was submitted to the following state agencies for an unofficial preliminary review: Department of Water Resources (DWR), Department of Environmental Quality (DEQ), Natural Resources Commission (NRC), Department of Health (DOH), Game and Parks Commission (G & P), and The University of Nebraska Conservation and Survey Division (CSD).

Although state statute does not require a formal approval by any state agency before the plan can be adopted and put into effect by the NRD, an attempt was made to address any comments or concerns presented by the responding agencies in the final draft of this plan.

The final draft of this plan was submitted to the Department of Water Resources, as the coordinating state agency, on December 1, 1993. After final review by the agencies mentioned above, approval of this plan by DWR was received on February 3, 1994.

10.1.3. Public Hearing

After approval by the NPNRD Board of Directors, the Groundwater Management Plan was presented at a public hearing. An attempt was made to address any questions and comments presented by the public at that meeting and to reflect any changes made in the final draft of the plan.

10.2. Future Reviews and Assessments

Recognizing that a Groundwater Management Plan is a flexible and dynamic document that must respond to changing needs and conditions, it is the intention of the NPNRD Board of Directors that this plan be reviewed at least annually and any actions determined necessary be brought before the Board for action. This review may be accomplished by the Board itself, by a subcommittee of Board members, by the NRD staff, or by any group of knowledgeable and interested persons, as determined by the Board of Directors.

The annual review will include, but not be limited to, the following items:

1. Review progress of ongoing programs in meeting the objectives stated in Section 8.0 of this plan.
2. Review results of monitoring well sampling and any other water sampling since the last review. Special attention will be paid to high contaminant readings, and trends will be examined to determine if a contamination problem is developing or has developed.
3. Review the lists of contaminants and MCL levels in Appendix 11.3. The DEQ and DOH will be contacted to determine if any changes or additions have been made to these lists.

If the review committee determines that action is required to address any problems or areas of concern, then the problem and a list of recommended actions will be presented to the full Board of Directors for their consideration. Examples of recommended actions could include, but not be limited to, the following:

1) Recommend further investigative efforts in areas where possible problems are occurring.
2) Recommend that certain programs be given priority in time and budget in order to speed progress in those programs.
3) Recommend that contingency actions presented in this plan be enacted. (For example, a groundwater management sub-area be established and further controls be enacted in that area to respond to an increase in measured contamination.)
4) Recommend that the plan itself be revised to reflect unforseen or newly arisen problems. In this case, the plan is to be officially revised through a public hearing process. It should be noted that state law limits this type of major plan revision to once annually.

The review committee's findings will be presented to the NRD Board of Directors. The presentation may be in the form of an oral report, a written report, or any other form of report presentation, as desired by the Board. The Board will then discuss and act on any recommendations made by the review committee within a reasonable time frame, reasonableness being determined by the criticality of the problems and recommendations.

Figure 2.1.2.2.2-1. Hydrograph of Observation Well in Banner County

Figure 2.1.2.4.1.1-1. Hydrograph of Scottsbluff Recorder Well (Reference 180)

Figure 2.1.2.4.1.3-1. Hydrograph of Crescent Lake Well (Reference 180)

Figure 3.1.1-1. Well Schedule Form (Sheet 1)

Figure 3.1.1-1. Well Schedule Form (Sheet 2)

Figure 3.1.1-1. Well Schedule Form (Sheet 3)

Figure 3.1.1-1. Well Schedule Form (Sheet 4)

Figure 3.1.1-1. Well Schedule Form (Sheet 5)

Figure 3.1.1-1. Well Schedule Form (Sheet 6)

Figure 3.1.1-1. Well Schedule Form (Sheet 7)

Figure 3.1.1-1. Well Schedule Form (Sheet 8)

Figure 3.1.1-2. Well Sampling Form (Sheet 1)

Figure 3.1.1-2. Well Sampling Form (Sheet 2)

Figure 3.1.1-2. Well Sampling Form (Sheet 3)

TABLE 5.2.2.1-1

Figure 5.2.2.1-1

Figure 5.2.2.2-1

Figure 5.2.2.1-2
Annual Contribution From Drains
North Platte River
Wyoming-Nebraska State Line to Bridgeport
(Values in Acre-Feet)
(Reference 181)