A Report of Preliminary Findings from

A Study of Hydrologically Connected Ground and Surface Water and its Contribution to Conflicts between Ground Water Users and Surface Water Appropriators in the North Platte Natural Resources District

The Nebraska Department of Natural Resources

Roger Patterson, Director

February 2004

A Study of Hydrologically Connected Ground and Surface Water and its Contribution to Conflicts between Ground Water Users and Surface Water Appropriators in the North Platte Natural Resources District

Summary

On September 5, 2002, the North Platte Natural Resources District (NPNRD) sent a letter requesting the Department of Natural Resources (DNR) to consult with the NPNRD concerning studies and a hearing on the preparation of a joint action plan for the integrated management of hydrologically connected ground water and surface water under the Nebraska Ground Water Management and Protection Act, Section 46-656.28.

This study addresses the NPNRD's request. It specifically addresses 1) the causes of any conflicts, disputes or difficulties resulting from the conjunctive use of hydrologically connected ground water and surface water resources, 2) the extent of the areas affected by such conflicts, disputes or difficulties in the North Platte Natural Resources District and 3) the question of whether a joint action plan could reduce or eliminate the causes of conflict.

To conduct this study the DNR examined available data from previous studies for the area. Many studies have been conducted by the United States Geological Survey and other entities concerning the hydrogeology of this area, especially the area involving the large surface water canals in the North Platte River Valley. The Department determined that the existing data was adequate to make the determination regarding the cause of the conflicts in the NPNRD and the extent of the area affected. For the purposes of this study, the NPNRD was divided into three study areas the North Platte Valley, the Northern Tablelands – Sand Hills and the Southern Tablelands. These areas are distinguished by different geological and hydrological characteristics.

In the **North Platte Valley** study area the ground water and surface water are very closely connected. Surface water appropriators along the North Platte River and its tributaries divert water stored in reservoirs in Wyoming. Water from these diversions seeps from the canals and irrigated fields and fills the alluvial ground water aquifer between the canals and the river. This seepage turned historically dry or intermittent streams into perennially flowing streams. Surface water supplies in this area are often inadequate to fill the needs of the irrigation districts. Since the 1970's many irrigators have drilled ground water wells in order to supplement existing surface water supplies and irrigate new land. As a result of inadequate supplies, in 1993 the then Department of Water Resources declared a moratorium on issuing new surface water permits. Since 1993, 1,345 new depletive wells, including 350 irrigation wells, were drilled in aquifers connected to the North Platte River. Water consumed by these wells has further depleted stream flows. Because of the high degree of interdependence between the ground water and the canals and because of the fact that the surface water supply is over appropriated, the additional consumptive use due to wells that are hydrologically connected to the river is reducing surface water supplies and is contributing to conflicts

between ground water users and surface water appropriators. The extent of the area affected is the entire North Platte Valley study area.

In the **Northern Tablelands – Sand Hills** study area the hydrologic connection between ground water and surface water extends to Blue Creek and the North Platte River. Here ground water flows mainly from west to east and drains through Blue Creek. Currently there are 14 surface water permits on Blue Creek and 383 high capacity wells in this area. The number of registered wells completed in this area has been steadily increasing since the 1970's. A monitoring well in this area shows localized water level declines of 12 feet since the mid-1980s. Statistical analysis shows a significant declining trend of average annual flows on Blue Creek between 1961 and 2002. Surface water irrigators on Blue Creek are shut off due to an inadequate amount of stream flow in most years. Continued development of ground water wells will cause further water level declines. The nature of hydrologically connected ground water and surface water dictates that any water level decline will impact the stream. Therefore, ground water wells that further deplete stream flows in an area already subject to frequent regulation of surface water diversions is contributing to conflicts between ground water users and surface water appropriators. In addition to the conflicts within the study area, because the ground water is connected to the North Platte River, the conflicts of the North Platte Valley study area also apply to this study area. The extent of the area affected is the entire study area.

In the **Southern Tablelands** study area the ground water is also hydrologically connected to the over appropriated North Platte River; therefore, additional depletions to the river from ground water wells are also contributing to the conflicts between surface water appropriators and ground water users. The extent of the area affected is the entire study area.

Because the conflicts are caused by the increased consumptive use of ground water in an over appropriated surface water system, better management via a joint action plan of the ground water resources as an integral part of the surface water system will reduce or eliminate the causes of conflict.

I. Introduction

Background and Authority

The State of Nebraska recognized the relationship between ground and surface water with the passage of LB 108. According to Nebraska law, surface water is regulated by the Department of Natural Resources and ground water is regulated by the 23 Natural Resources Districts. To address the separation of powers, § 46-656.28 allows a Natural Resources District to request a study from the Department of Natural Resources (DNR) to examine the interaction of hydrologically connected ground and surface water and develop a joint action plan.

In § 46-656.28(2), the Director of the DNR is charged with making a preliminary determination of whether there is a reason to believe that the use of hydrologically connected ground water and surface water resources is contributing to or is in the reasonably foreseeable future likely to contribute to (a) conflicts between surface water appropriators and ground water users (b) disputes over interstate compacts, or (c) difficulties fulfilling the provisions of other formal state contracts or agreements.

On September 5, 2002, the North Platte Natural Resources District (NPNRD) sent a letter requesting the DNR to consult with the NPNRD concerning studies and the possible preparation of a joint action plan for the integrated management of hydrologically connected ground water and surface water under the Nebraska Ground Water Management and Protection Act. The DNR responded on November 1, 2002, with a preliminary decision according to subsection (2) of Section 46-656.28, R.R.S., 1998. The DNR found reason to believe that the use of hydrologically connected ground water and surface water resources in the NPNRD is contributing to or is in the reasonably foreseeable future likely to contribute to conflicts between ground water users and surface water appropriators. This decision was made based on information found in the NPNRD's ground water management plan (GWMP) and other records, various United States Geological Survey (USGS) reports and various DNR records. A copy of both letters can be found in Appendix I.

Based upon the preliminary determination, the DNR initiated a more detailed study to determine the cause of such conflicts, disputes or difficulties and the extent of the area affected. Within 90 days of completing the study the Director is to issue a written report of preliminary findings and makes a determination as to whether or not the conflicts between surface water appropriators and ground water users could be eliminated or reduced through the exercise of the authority granted in § 46-565.28(5).

Acknowledgements

The study was overseen by the Deputy Director of DNR, Ann Bleed. Jennifer J. Schellpeper of the DNR Planning Department was the primary author of the study with Shuhai Zheng also of the DNR Planning Department as primary author of Appendix II. Tom Hayden of the Bridgeport Field Office and Jim Cannia of the North Platte Natural Resources District provided important suggestions to the study. Thanks are due to Tina Kurtz for her many reviews of the study and editorial comments.

Study Methodology

The major objectives of the study were to 1) determine the extent of the area affected i.e. extent of the area with a hydrologic connection between ground water and surface water within which conflicts among water uses are occurring, and 2) the cause of (a) conflicts between ground water users and surface water appropriators, (b) disputes over interstate compacts or decrees or (c) difficulties fulfilling the provisions of other formal state contracts or agreements which have resulted from the use of any hydrologically connected ground water and surface water now or in the reasonably foreseeable future.

To meet the first objective the hydrogeology of the study area needed to be understood. DNR reviewed the available data from a variety of sources such as the Bureau of Reclamation (BOR), DNR, USGS, NPNRD, Conservation and Survey Division (CSD) and others. These data included but were not limited to geologic cross sections, water table maps, water chemistry, surface water canal diversions, stream gage records and precipitation records. To determine whether conflicts existed, the DNR examined water administration records and logged complaints of insufficient water. After consideration of the available data the DNR decided that both objectives could be met using the data and information that were already available; no new study to gather more data was needed.

Since 2001, this area has suffered from one of the most extreme droughts of the century. In droughts, lack of sufficient water supplies is likely to cause conflicts between surface water appropriators and ground water users that would not occur under more normal conditions. While conducting this study, the DNR did not focus on data pertaining to this recent severe drought. Rather the examination and conclusions are based on more normal wet and dry cycles since the 1960's.

The initial review of data revealed three distinct areas of hydrologically connected surface water and ground water. Characteristics such as type of surface water system, topography, principal aquifer properties, the water table and existing management sub-areas determined the relative boundaries of the three study areas. The study report was organized according to these study areas.

For each area the nature of the hydrologic connection between surface water and ground water was determined by examining whether the geologic materials were capable of transmitting water, the water table indicated a connection between ground water and surface water flows, the stream gage records showed evidence of base flow at some point in time or other evidence from previous studies concluding that the stream and ground water were in hydrologic connection. Hydrogeologic characteristics examined in determining whether or not a geologic formation was capable of transmitting water included hydraulic conductivity, which is defined as the volume of water that will flow through a unit cross-sectional area of aquifer in unit time, under a unit hydraulic gradient and at a specified temperature, and transmissivity which is the hydraulic conductivity multiplied by the full thickness of saturated aquifer.

Once a hydrologic connection was determined in a study area, the second objective of the study is to determine if there is evidence of current or future conflicts between surface water appropriators and ground water users in the area. To make this determination the DNR had to find that both surface water appropriators and ground water users relied on the hydrologically connected ground water supplies and that these supplies were not sufficient to meet all uses resulting in a conflict among users.

As part of this study, Shuhai Zheng of the DNR completed a report using statistical analysis to determine possible relationships between the various parameters which control the amount of stream flow. The parameters included canal diversions, stream flows, precipitation, the number of registered ground water wells and surface water acreage data. A complete copy of this report can be found in Appendix II.

<u>General Conclusions</u>

In almost all areas of the NPNRD the ground water is connected with and is flowing toward the North Platte River or one of its tributaries, indicating that the majority of the ground water in the NPNRD supplies flow to the North Platte River. Only a small area of ground water in the northern portion of the NPNRD flows into Box Butte County and the Upper Niobrara White Natural Resources District (UNWNRD). Thus, in all cases it was determined that the geologic formations surrounding the stream network were in hydrologic connection with the streams to varying degrees.

Data from the DNR showed both surface water appropriators and ground water users were present in each study area as well as in outside areas which could also potentially be affected by the use of hydrologically connected ground water and surface water in the study area. Hydrogeologic evidence linked all of the study areas to the North Platte River and its tributaries. In most years surface water rights are closed because of insufficient stream flow. In 1993, the DNR determined that due to insufficient stream flow the North Platte River above Lake McConaughy should be closed to any new surface water appropriations. Therefore, any new use of surface water or hydrologically connected ground water that increases the consumptive use of water would injure an existing senior surface water appropriator or ground water user and increase conflict.

<u>Basic Principles of Ground Water - Surface Water Interactions</u>

1) Where there is a hydrological connection between surface water flow and ground water aquifers, a consumptive use of one depletes the supply in the other.

2) In such areas a decrease in surface water supplies, precipitation, canal seepage or seepage from irrigated fields, will decrease the amount of water infiltrating from the land surface to recharge the ground water aquifer. A decrease in recharge will decrease the ground water supplies available for use.

3) Stream flows are supplied by surface water runoff and by water seeping from the ground water aquifer to the stream as baseflow. Surface water runoff tends to be sporadic, depending on precipitation events. Baseflow from ground water is more constant.

4) Changes in baseflow to a stream result from any factor that either changes the water pressure in the aquifer or the water table elevation. Consumptive use of the aquifer by wells or vegetation affects both the aquifer pressure and water table elevation.

5) If a ground water aquifer is closely connected to a surface water stream, decreases in aquifer water pressure or elevation will either decrease the movement of water to the stream or induce the movement of water from the stream to the aquifer. In either case, the first noticeable impact of increased consumptive use from an aquifer hydrologically connected to a stream will likely be a change in the quantity of stream flow rather than a change in the water table elevation of the aquifer. In many cases, changes in water table elevations are detected only when stream flows decline to the point they are no longer able to recharge the aquifer. Thus, any steady decline in stream flow that cannot be explained by a change in precipitation or other factors affecting ground water recharge is a good indication that current level of consumptive use of the hydrologically connected ground water aquifer cannot be sustained in the long term.

6) Aquifer Properties: Hydraulic Conductivity (K) – the volume of water that will flow through a unit cross-sectional area of aquifer in unit time, under a unit hydraulic gradient and at a specified temperature, basically K is a measure of how easily water flows through the aquifer. For instance, water flows much easier through a sand and gravel aquifer than an aquifer composed of silts and clays; Transmissivity (T) – the hydraulic conductivity multiplied by the full thickness of saturated aquifer. The more saturated thickness the higher the value of T; Saturated Thickness – the thickness of the aquifer where all available pore space is filled with water.

Study Area – The NPNRD

The NPNRD is bounded on the west by the state line of Nebraska and on the east by the eastern edge of Garden County, Nebraska. The southern border follows the southern boundaries of Garden, Morrill and Banner Counties. The northern border follows the northern boundaries of Morrill and Garden Counties and the northern boundary of Township 26 across southern Sioux County. The North Platte River, which runs northwest to southeast through the NPNRD, rises in the mountains of northern Colorado, flows north through the mountains of southern Wyoming and then east through the plains of central and eastern Wyoming and western Nebraska. Pumpkin Creek is a major tributary to the North Platte River in this area (App. III Figure 1)[1].

Topographically, the NPNRD varies from flat valley lands and terraces along the river to rugged bluffs and escarpments along the valley sides. In the northeast is the Sand Hills area and to the north and south of the North Platte River Valley lie the plains (App. III Figure 2). Figure 3 in App. III is a digital elevation map of the NPNRD. The basic stream network, major canals and laterals can also be seen on this figure. The numerous lakes and dunes of the Sand Hills region are a prominent feature in the northeast corner of the figure, as are the rugged bluffs and valley side slopes along the North Platte River.

[1] All Figures larger than 8.5 by 11 inches are in Appendix III (App.III).

Annual precipitation at the Mitchell 5E Station ID 25-5590 in the NPNRD has minimum, maximum and average values of 5.68, 19.64 and 13.15 inches respectively for the period of record 1931 to 1998. Annual precipitation at the Crescent Lake National Wildlife Refuge Station ID: 25-2000 in the NPNRD has minimum, maximum and average values of 10.24, 26.22 and 17.03 inches respectively for the period of record 1949 to 2002. Precipitation data were retrieved from the DNR website Data Bank. Figure 1 shows the 30 year precipitation normals for four stations located throughout the NPNRD. The figure indicates that since 1941, the most recent 30 year period, 1971-2000, has had precipitation normals greater at the Scottsbluff and Bridgeport stations than any previous 30 year normals, and at the Oshkosh and Crescent Lake stations, precipitation normals are higher than the driest 30 year normal for each station.

Land cover in the NPNRD consists primarily of range land, dry land and irrigated crop land. The primary crops grown in the area are dry beans, corn, alfalfa and winter wheat. A more complete listing of crops and an approximate aerial distribution can be found in App. III Figure 4. The irrigated crops are concentrated in the valley areas and those areas of the tablelands where topography, soils and depth to water make irrigation practical. There is a lack of cropland in the northwest corner and Sand Hills region of the NPNRD; this can be attributed partly to the soils which are not suitable for cropland and the topography in the area.

The boundaries of the DNR surface water division 1A and lands irrigated with surface water via the major canals as well as the canals and laterals themselves are shown in Figure 5 of App. III. (Table 1 in Appendix IV lists the surface water appropriations in the NPNRD. A stick diagram of the canal network can be seen in Appendix II Figure 1.) Ground water wells used for irrigation and surface water appropriation diversion points are also shown on Figure 5 App. III, including areas outside of the NPNRD. The NPNRD has a large number of both surface and ground water users. There are 27 surface water irrigation districts in the NPNRD supplying water to more than 360,000 acres. Figure 2 shows the cumulative number of surface water appropriations in the NPNRD by priority year. The largest numbers of appropriations are for irrigation. As of October 20, 2003, there were approximately 2,150 non-replacement, non-abandoned registered irrigation wells and 3,794 depletive wells in the NPNRD, excluding the wells in the Pumpkin Creek Management Sub-Area (Figure 3). Depletive wells are those wells that consume water and thus remove water from the ground water system. Depletive wells include uses for: aquaculture, commercial, domestic, irrigation, public water supply, dewatering, stock, and other, except those in the other category noted as sparge, vapor extraction, or another non-consumptive use. The irrigation wells supply water to more than 150,000 acres of land, including lands commingled with surface water and lands solely irrigated with ground water. To the north of the NPNRD, in Box Butte County in the UNWNRD, there is a large concentration of irrigation wells, approximately 1,200. To the south in the South Platte Natural Resources District (SPNRD), there are numerous irrigation wells in the valley of Lodgepole Creek.

Figure 6 in App. III shows five geologic cross-sections, which are located near or pass through the NPNRD, and a surface map showing the locations of the cross-sections. A-A', B-B' and C-C' are north to south cross-sections moving from west to east respectively. D-D' and E-E' are northeast to southwest cross-sections. The underlying bedrock is predominantly Pierre Shale; above this lies various undifferentiated Cretaceous deposits, the Chadron Formation, Brule Formation, Arikaree Group, Ogallala Group, Pliocene deposits and Quaternary deposits including the Sand Hills, which are easily recognizable on the C-C' and E-E' cross-sections.

In 1969, ground water regions across the state of Nebraska were defined by the CSD in cooperation with the then Department of Water Resources and the Nebraska Soil and Water Conservation Commission. There are four distinct ground water regions within the NPNRD: the Platte River Valley, the Northern Panhandle Tablelands, the Sand Hills and the Southern Panhandle Tablelands (App. III Figure 7). A more detailed description of the principal aquifers in the NPNRD is shown on a map compiled by the CSD in 1993 for the NPNRD's GWMP (App. III Figure 8). The principal aquifers include Undifferentiated Cretaceous, Chadron Sand, Brule, Arikaree, Ogallala, Sand Hills and Alluvium. The hydrogeologic properties of these aquifers are quite varied and are discussed in more detail later in this study.

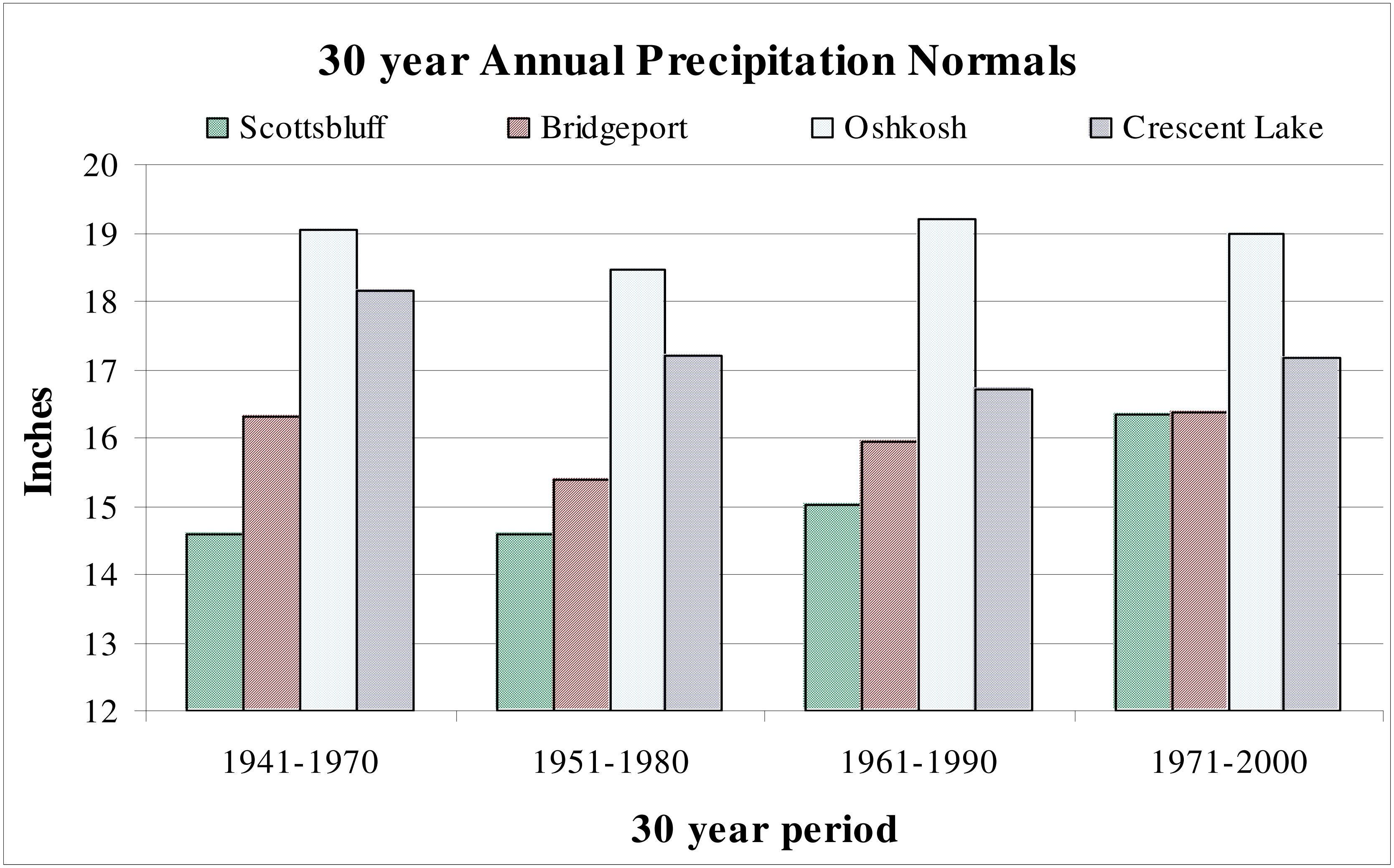


Figure 1: 30 year annual precipitation normals at four weather stations located within the NPNRD, Scottsbluff AP #185, Bridgeport #030, Oshkosh 8 SW #162 and Crescent Lake #048, according to United States Department of Commerce: Climatography of the United States No 81.

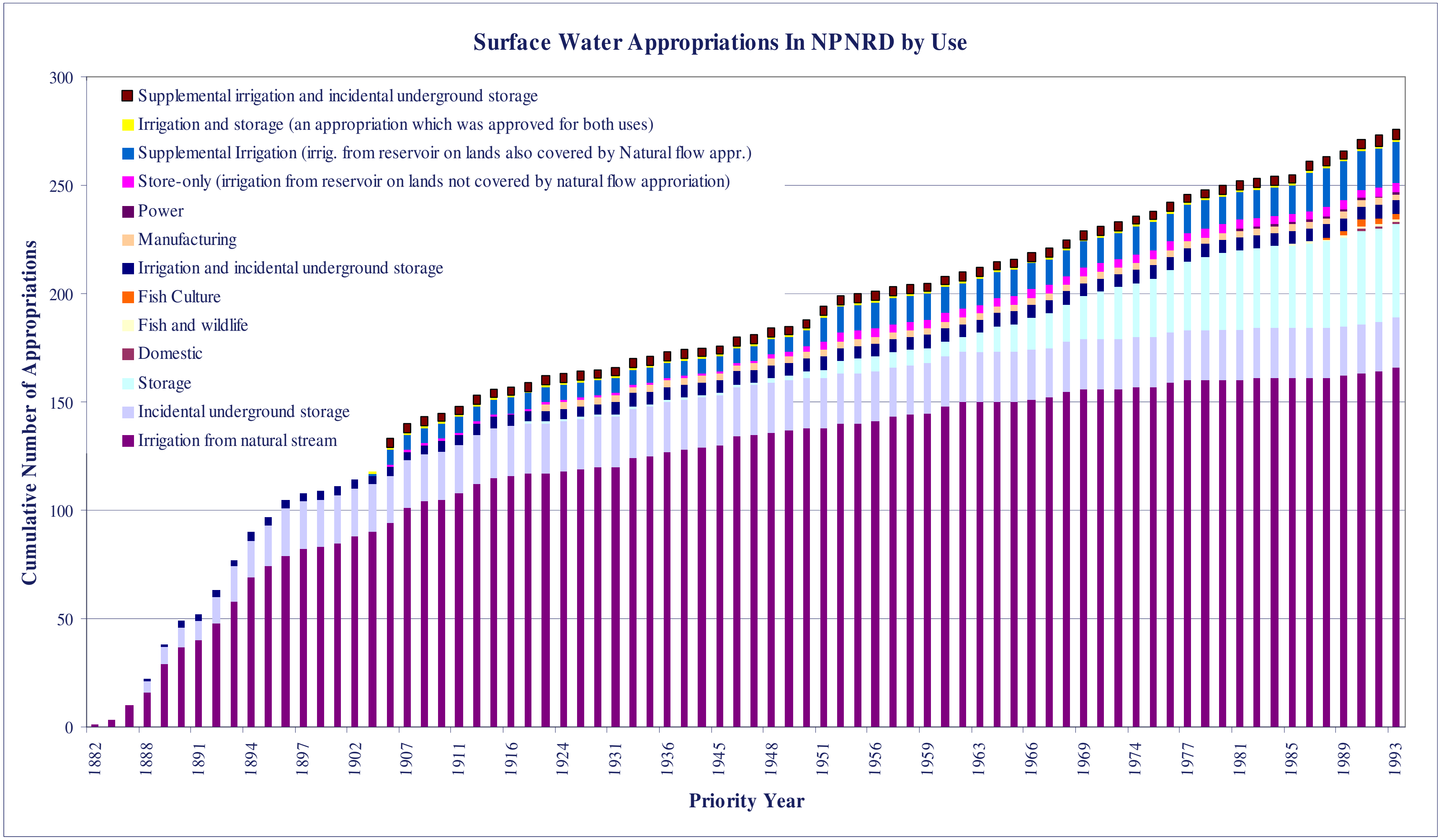


Figure 2: Surface water appropriations in the NPNRD listed by priority year and approved use.

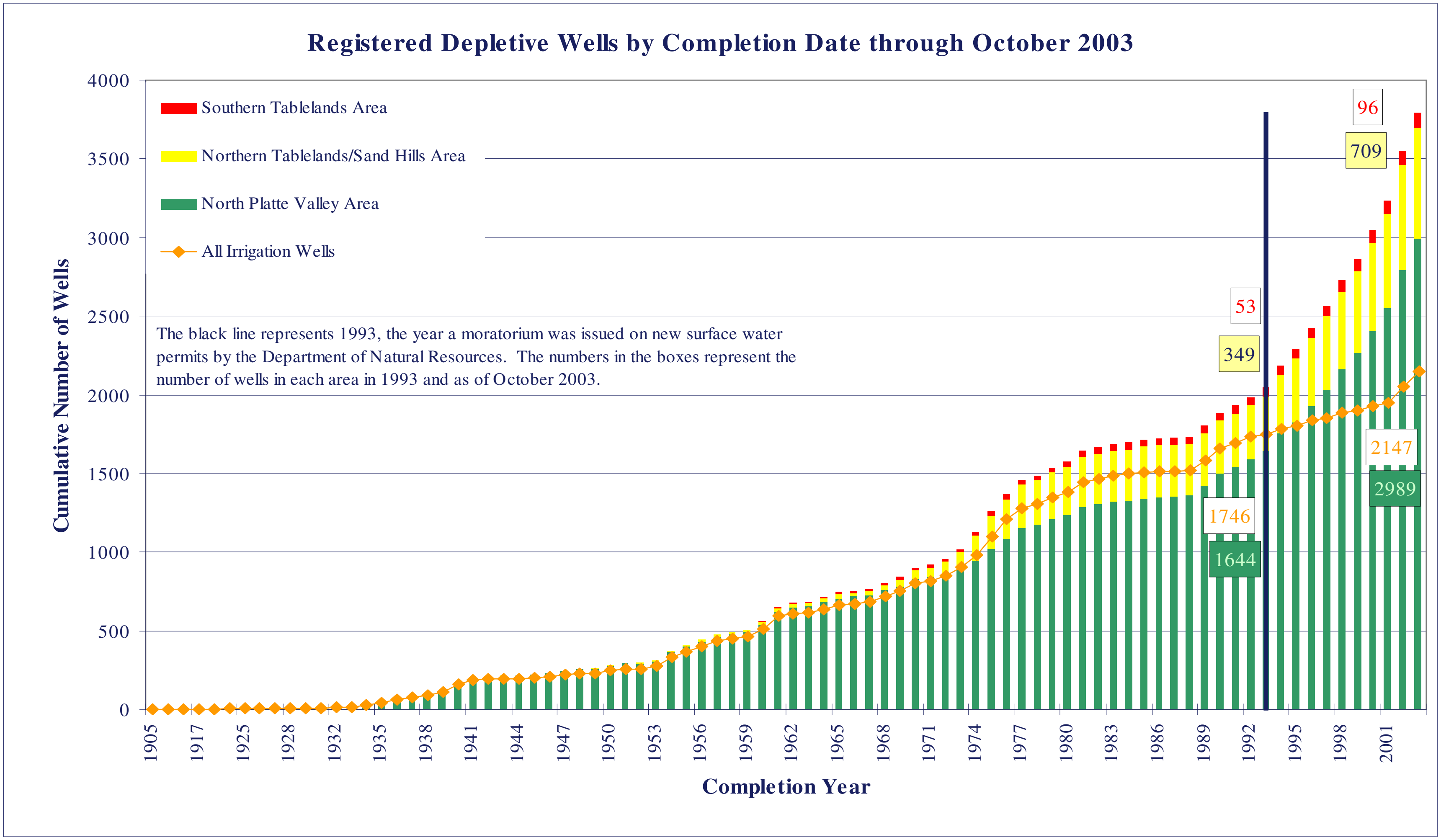


Figure 3: This graph is of registered wells only. In 1993 the Department of Water Resources began to require stock and domestic wells to be registered. This will account for some of the steep increases in depletive wells after 1993. Depletive wells include those with the following uses: aquaculture, commercial, domestic, irrigation, public water supply, dewatering, stock, and other, except those in the other category noted as sparge, vapor extraction, or another non-consumptive use.

The water table in the NPNRD and surrounding area from the spring of 1995, as developed by Vince Dreezen and others with the CSD, shows areas of recharge and discharge (App. III Figure 9). A major area of recharge, where surface water infiltrates to the ground water, is reflected in the water table contour map as an area of higher water table elevation and occurs in the Sand Hills region in the northeast corner of the map. There is also a ground water table high located in the northwestern corner of the map. Both of these water table highs cross the boundary between the NPNRD and the UNWNRD. Discharge areas, where ground water emerges onto the land surface, can be seen along the major streams in the NPNRD including the North Platte River and Blue Creek. Ground water flows into the NPNRD in the west and leaves the NPNRD along its eastern boundary, generally flowing from west to east. More maps including depth to water, transmissivity, base of principal aquifer, saturated thickness, ground water in storage, specific yield, the water table in 1979 and 1987, average annual precipitation and others can be found in the NPNRD's 1993 GWMP.

Currently the NPNRD has a District-wide Ground Water Management Area and two Ground Water Management Sub-Areas (App. III Figure 10). The Lisco-Oshkosh-Lewellen Sub-Area, established in 1999, includes regulatory controls to address existing and potential nitrate contamination concerns. Since this sub-area does not speak to the issue of integrated management of ground water and surface water, it will be included in this study. The Pumpkin Creek Basin Ground Water Management Sub-Area was created in 2001 to provide for integrated management of ground and surface water and to address ground water quality and quantity issues. Regulatory controls established for the Pumpkin Creek Sub-Area include a moratorium on new water well permits and an allocation of ground water use. Because of the existing regulations, the Pumpkin Creek Sub-Area will not be included in the study area for consideration in this possible joint action plan.

Based upon characteristics such as the nature of the surface water system, topography, principal aquifer properties and existing management sub-areas, the NPNRD was divided into three study areas (App. III Figure 11). The central region is called the North Platte Valley area and is approximately defined by the valley side slopes, escarpments or the extent of the canals on the north side of the river, whichever is further from the river. The southern border follows the existing Pumpkin Creek Sub-Area boundary as far east as possible and then follows the valley side slopes. South of the North Platte Valley area, but excluding the Pumpkin Creek Sub-Area, lie the Southern Tablelands. To the north is the Northern Tablelands – Sand Hills area. Both tableland areas consist of the Brule, Ogallala and Arikaree Aquifers. The Ogallala and Brule are predominant in the Southern Tablelands whereas the Northern Tablelands – Sand Hills area trends from a Brule and Arikaree predominant aquifer in the west to an Ogallala and Quaternary sands aquifer in the east (Appendix III Figure 6).

II. North Platte Valley Study Area

Hydrogeology – Extent of the Area Affected

Geology

From west of the NPNRD in Wyoming to Lake McConaughy the water in the North Platte River Valley flows through a narrow trough that Pliocene and Pleistocene geologic and hydrologic processes carved into the bedrock and then filled with highly permeable sands and gravels (Rapp et al., 1957; Morris and Babcock, 1960; Crist and Lowry, 1972; Wenzel et al., 1946). These sands and gravels lie in thick deposits beneath the bottomlands and parts of the lower terraces in the NPNRD. The hydraulic conductivity (K) in this region is in excess of 300 feet per day, and may range as high as several thousand feet per day. 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 (Olsson Associates, 1993).

The Brule Formation lies beneath a major portion of the alluvial sands and gravels in the valley region and can be found at the surface in the Bluffs and Escarpments north and south of the valley. The Brule consists primarily of silts and clays and has a minimal hydraulic conductivity of less than 25 feet per day (Olsson Associates 1993). In some areas there may be a significant saturated thickness that contains a great deal of water; however, as was mentioned above, the hydraulic conductivity of unfractured Brule is very low (Wenzel et al., 1946). Hence, a well drilled in this area can fill and be pumped, but a person may only get one casing volume of water and then have to wait days and/or months for the well to refill. However, channels of sandstone and fractures within portions of the Brule conduct water easily and have high transmissivity values ranging from 10,000 to 100,000 gallons per day-foot (Olsson Associates, 1993). The large range of transmissivities results from the variation in the fracture network. To be a viable source of ground water for irrigation, the fractures need to be well connected or have another source of water. In some areas the upper portion of the Brule Formation is significantly fractured. Any overlying Quaternary deposits such as alluvium and dune sand, which generally have high hydraulic conductivity, allow water to percolate down into the fractures. In these areas an economically viable ground water resource can be found. The same can be true in cases where the Ogallala Group overlies the Brule. 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. Water supplies from the Brule are greatest in areas nearest the surface water irrigation canals and least where precipitation is the source of recharge (Wenzel et al., 1946). The main sources of water supply in the outer portions of the North Platte River Valley are the fractures and perhaps the channel fill deposits in the Brule Formation.

In addition to the Brule Formation, the Chadron Formation and other undifferentiated Cretaceous rocks underlie the North Platte River Valley in Scotts Bluff County. Because the water quality in these aquifers is so poor and the depth to water is great, these aquifers are rarely developed. Typically, water is found under confined conditions and some wells were artesian when first drilled. In the western portion of Scotts Bluff County, the Chadron

Formation outcrops (Wenzel et al., 1946). The Chadron aquifer is confined by bentonitic mudstone and claystone of the Chadron confining unit, which is thought to underlie most of the area in the NPNRD west of Range 56 West and North of Township 22 North (Verstraeten et al., 1995). The extent of this confining layer throughout the NPNRD is unknown. A map of the extent and thickness of the Chadron Formation can be found as Figure 12-18 in the NPNRD's 1993 GWMP. Yields of wells range from only a few gallons per minute to 1,000 gallons per minute (Olsson Associates, 1993). These aquifers are only used when other sources of water are unavailable, mainly in the western portion of Scotts Bluff County (Wenzel, et al., 1946). If these aquifers are truly confined they are most likely not hydrologically connected to the surface water.

Ground water levels range from 0 to 100 feet below land surface. As can be seen from the water table contour map (App. III Figure 9), ground water flow direction is generally from west to east and toward the North Platte River and its tributaries.

Development of the Canal System

As described by Bleed (2000), snowmelt from the Rocky Mountains in Colorado and Wyoming is the primary source of water for the North Platte River. Prior to the construction of reservoirs and development of surface water irrigation in the valley, the flows on the North Platte River were high in the spring, but relatively low to zero in the summer and fall (Fremont, 1845; Smith, 1897; Channel, 1901; Eschner et al., 1981). Early reports indicate that there were no perennially flowing tributaries to the North Platte River between the state line and Bridgeport, Nebraska. Further downstream there was sufficient flow in Pumpkin Creek and Blue Creek for diversion (Darton, 1899; Willis, 1910; Wenzel et al. 1946; Rapp et al., 1957).

The building of reservoirs, which captured spring runoff for later summer releases, and the development of irrigation delivery systems between 1905 and 1925, allowed crops to be watered not just in the spring, but also in the summer, when the crops had the greatest need for water. Along with surface water irrigation development came surface water spills from canals and surface water runoff from fields (Bleed, 2000).

Thus, the major source of water for the North Platte River comes from Wyoming. Figure 4 shows the hydrograph of flows that enter Nebraska either from the North Platte River at the state line or from canals that divert water in Wyoming but serve land in Nebraska.

The high permeability of the valley geologic materials also allowed surface water leaked from canals to readily migrate to the water table, which is not far from the ground surface. Seepage from the canals and deep percolation of water applied to fields increased recharge to the ground water aquifer. In 1946, Wenzel, Cady and Waite observed that the importation of surface water was the major cause of ground water level rises in the valley, noting that the general rise in the water table was 10 feet and as much as 100 feet in some areas. They also noted that the water level fluctuations in alluvial wells coincided with diversions into nearby canals (Rapp et al., 1957). This affect can still be seen today. An example is the hydrograph of a well near Sheep Creek and the Interstate Canal (Figure 5). Figure 6 is a hydrograph of a well that is not influenced by a nearby canal. In this monitoring well there is no irrigation season upward flux, as the well is not located near a canal system, and the water level has declined nearly 23 feet since 1977.

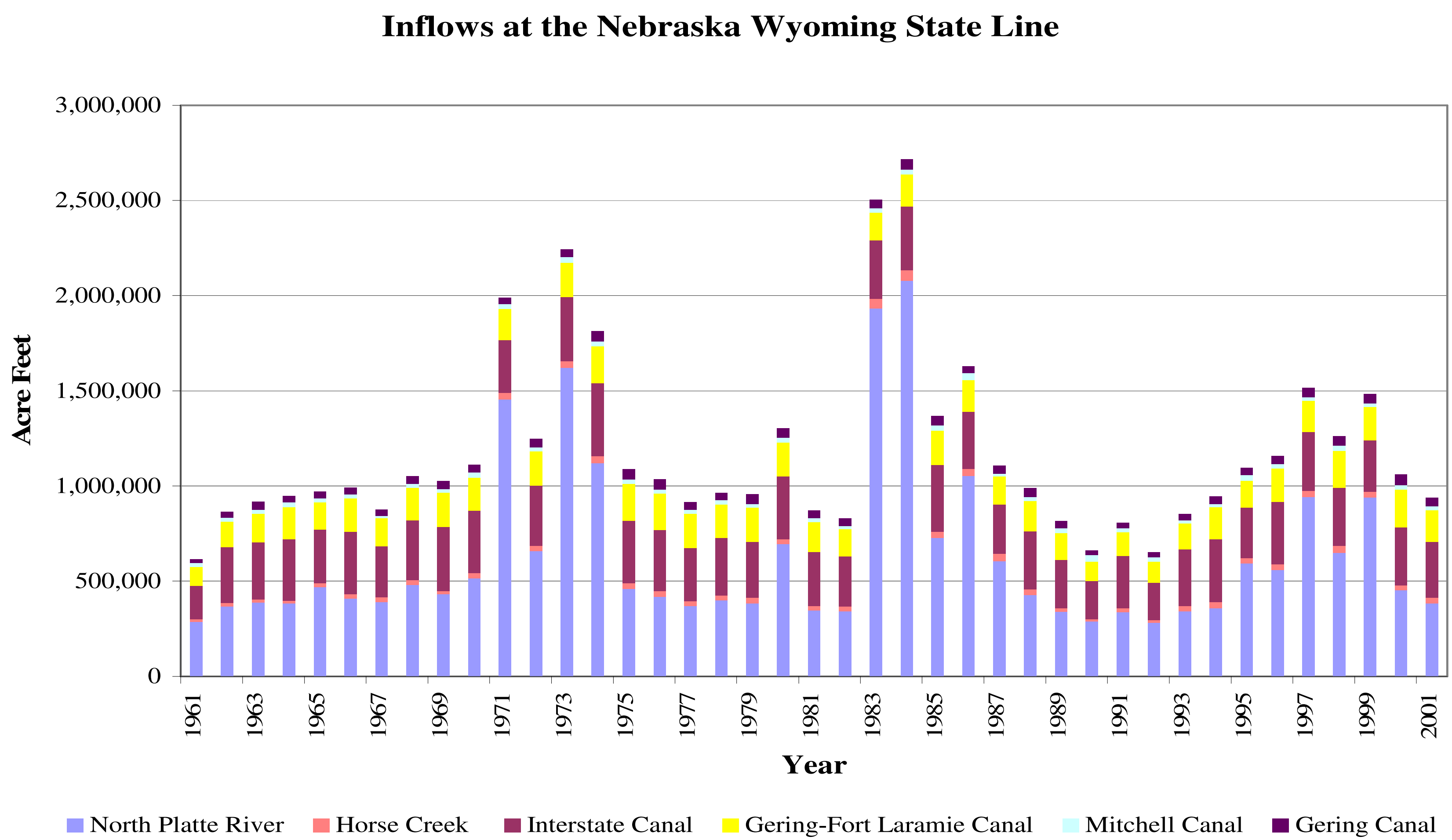


Figure 4: Inflows at the Nebraska – Wyoming state line. Interstate Canal, Gering-Ft. Laramie Canal and Horse Creek diversions were adjusted to reflect the amount of diverted flow that actually reached the state line (Adapted from Bleed, 2000).

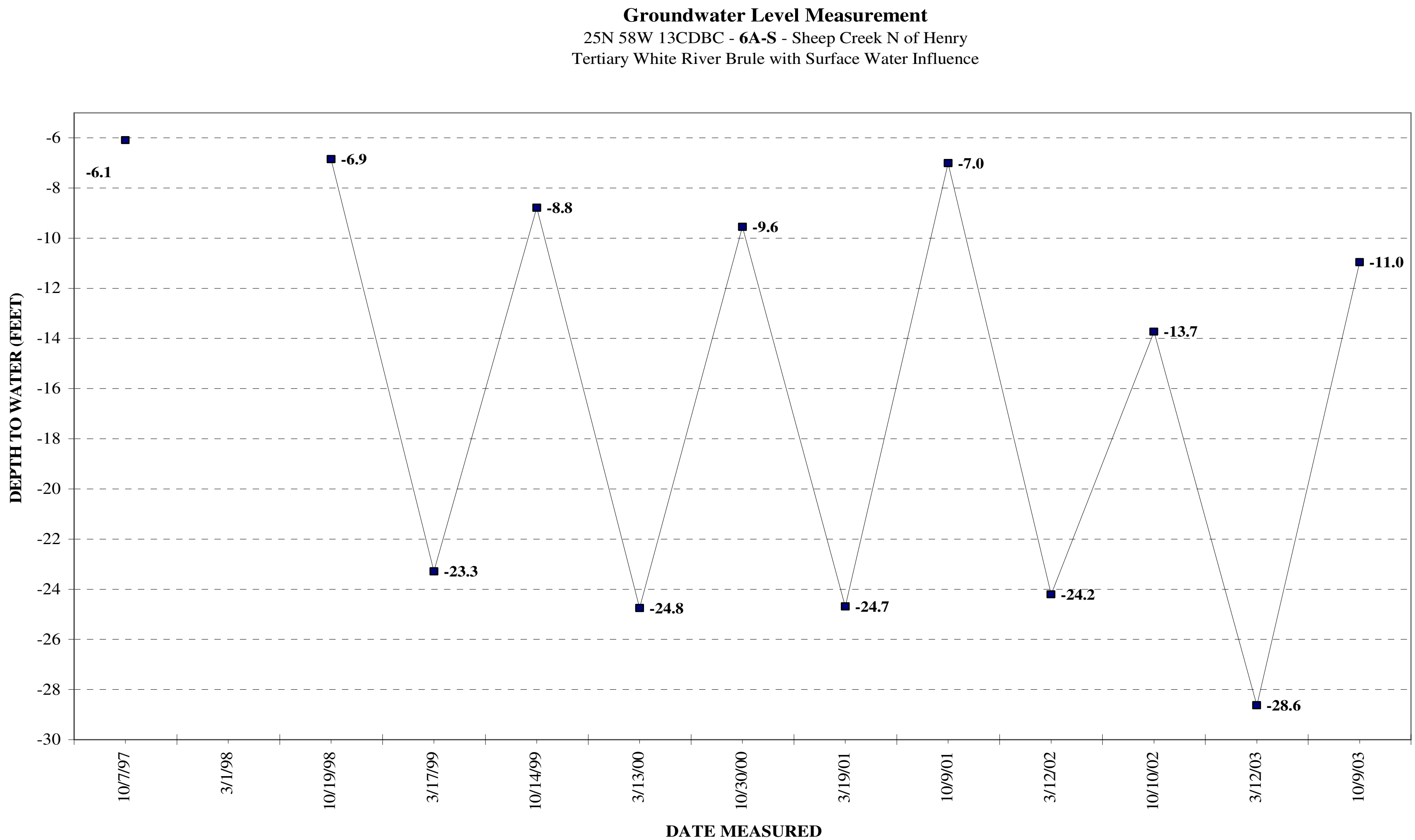


Figure 5: Hydrograph of a well near Sheep Creek and Interstate Canal, DNR registration number G-093083.

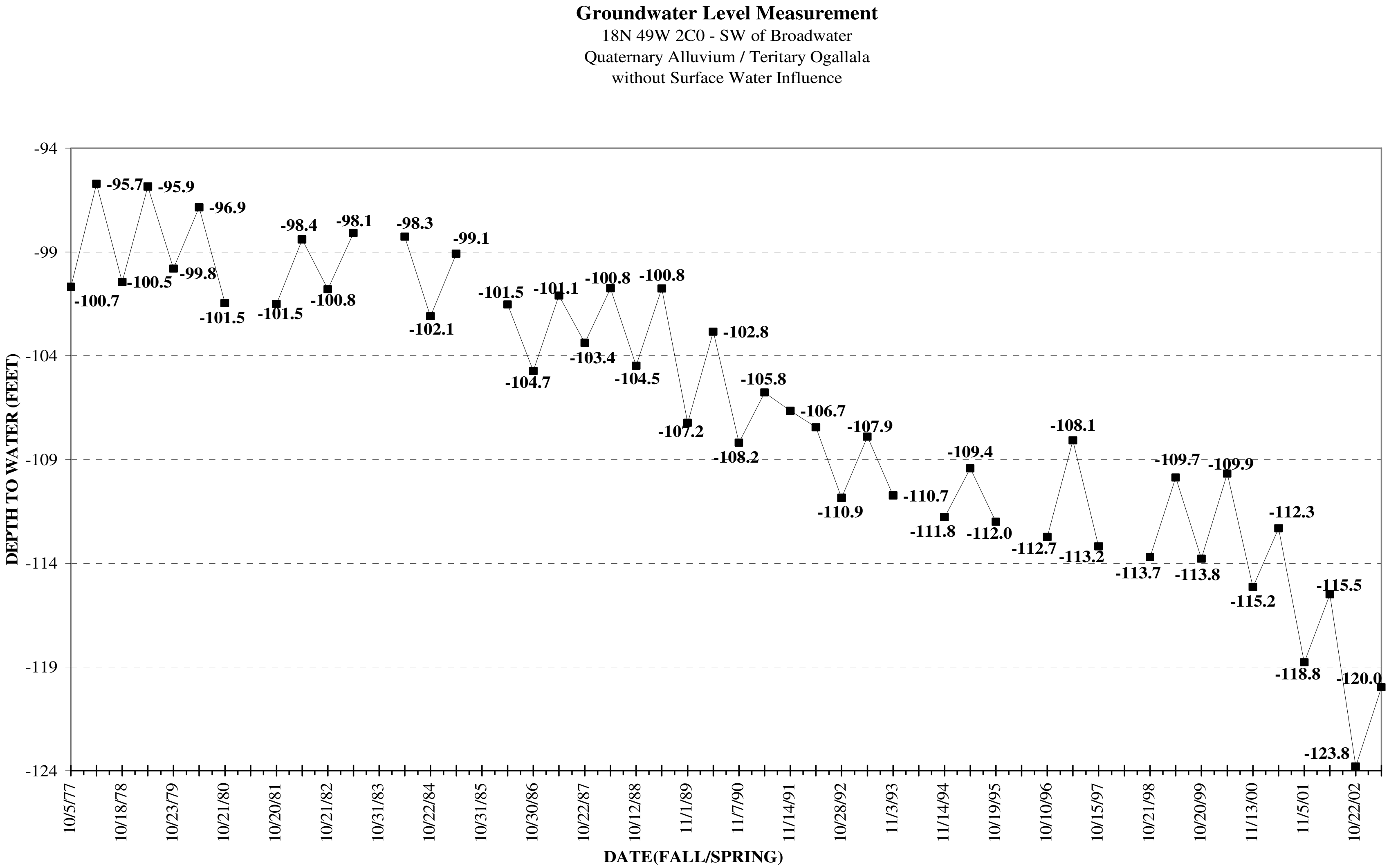


Figure 6: Hydrograph of a well not influenced by surface water canals, DNR Registration number G-029574.

As the ground water reservoir began to fill, it started to spill into low-lying areas creating wetlands. In 1911, there was no perceptible return flow west of Bridgeport (Willis, 1930), but between 1931 and 1938, the return flow between the state line and Minatare, Nebraska was over 326,000 acre feet (Wenzel et al., 1946). Eventually the combination of increased surface water runoff and higher water tables produced perennially flowing streams, such as Sheep Creek, Dry Spotted Tail Creek, Wet Spotted Tail Creek, Akers Draw, Nine Mile Creek and Tub Springs (See Figures 5 & 7 and tributary trend Figures in App. II). Some of these streams, such as Nine Mile Creek in Scotts Bluff County, now boast trout fisheries. Rapp et al. (1957) concluded that if irrigation diversions were terminated, these tributary flows would cease and the water table in the alluvial aquifer along the North Platte River would continue to drop (Figure7A). The dashed lines represent the projected water table elevation if the canal did not divert during the following irrigation season. The difference between the projected low water level and the high water level is approximately 8 feet/year. This significant influx of water to the ground water aquifer fills the alluvial aquifer in the areas influenced by the surface water canals and provides the major source of water for the many irrigation and domestic wells in the western portion of the NPNRD.

In a study of streambed hydraulic conductivity (K), David L. Rus et al. (2001) tested 10 sites in the Platte River watershed. In all cases, tests performed in the flood plain of the Platte or North Platte Rivers, the streambed contained no materials that would limit the ground and surface water interaction. Most of the K values ranged between 100 and 1,000 ft/d.

Figures 8 and 9 depict the basic hydrologic connection between a canal and the North Platte Valley respectively. In Figure 8 the leakage from the canal is creating a small ground water mound in the immediate area beneath the canal, similar to what is seen along canals in the North Platte Valley. Figure 9 shows a wider view of the system, which includes not only the large amount of recharge from deep percolation beneath irrigated fields and canal leakage, but also recharge from precipitation and discharge to evapotranspiration. The configuration of the bedrock and ground water flow are also depicted.

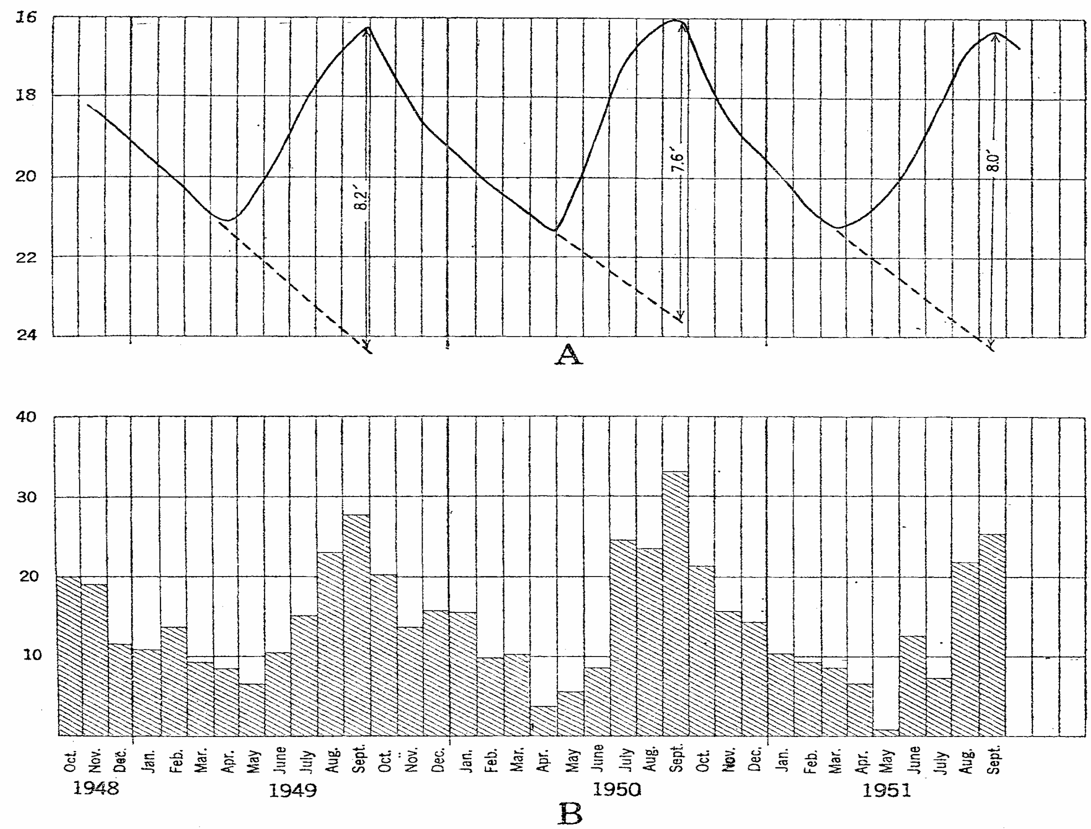


Figure 7: Hydrographs showing (A) the average water level in 12 wells in the valley fill, and (B) the invisible pickup in the North Platte River between Whalen Dam and the Wyoming-Nebraska State line (Rapp et. al, 1957).

Schematic Hydrologic Models

Basic Canal

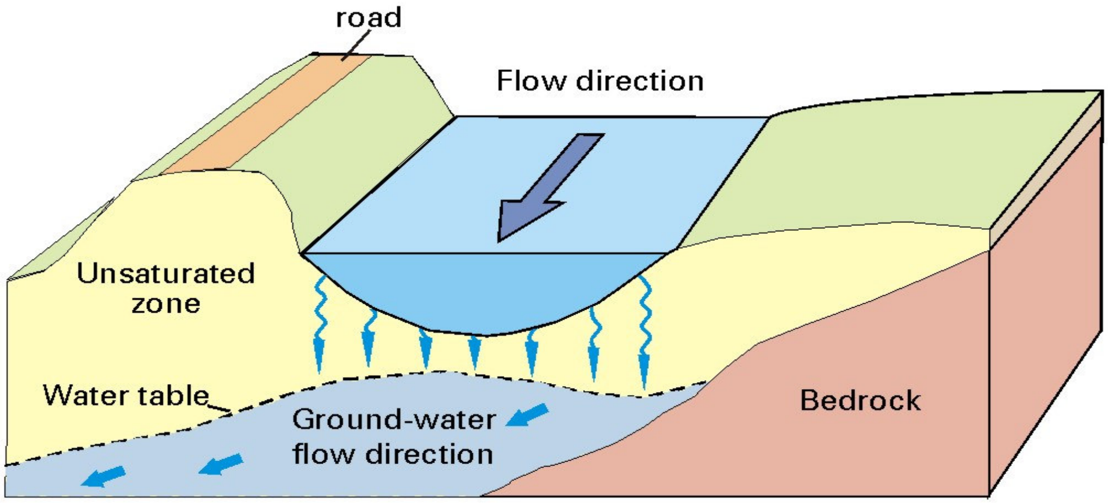


Figure 8: Canal leaking surface water to the ground water table.

North Platte Valley

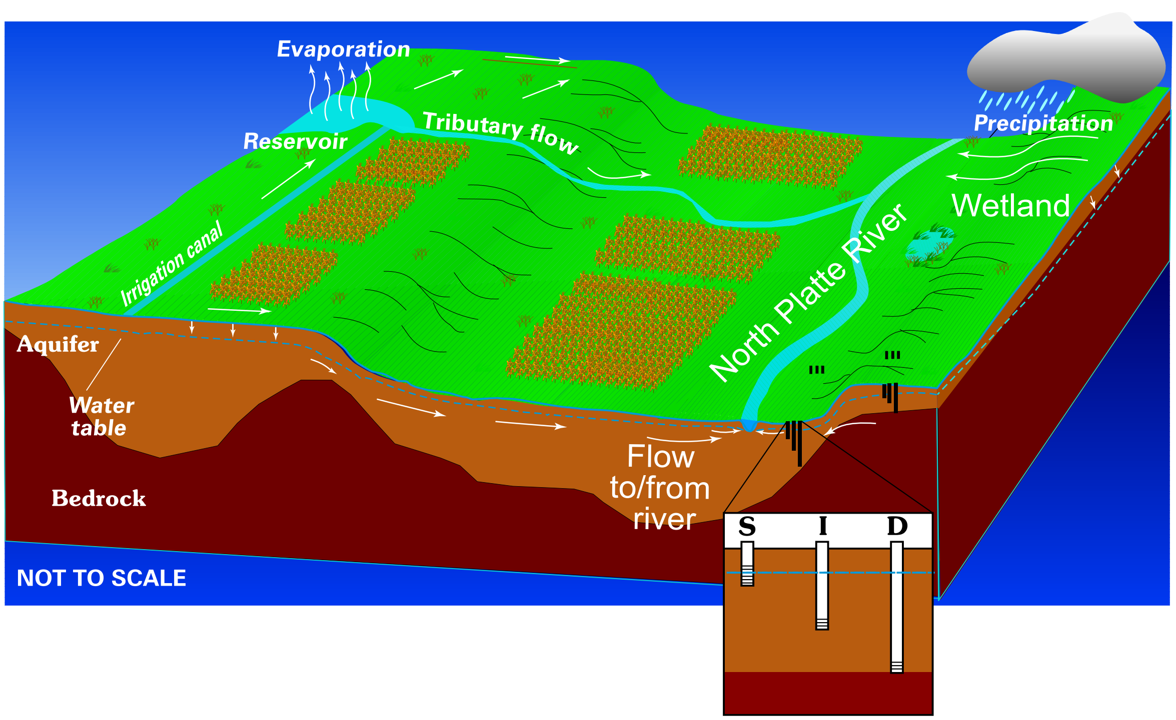


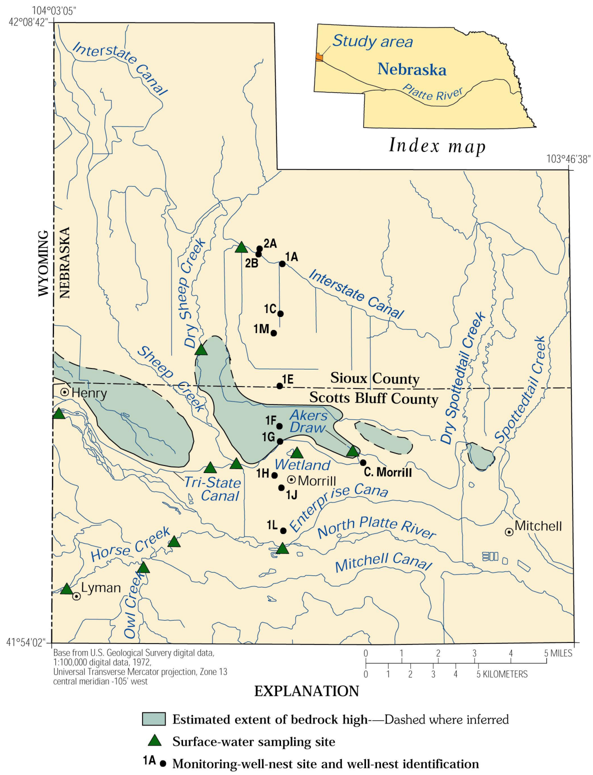
Figure 9: Modified from Winter and others, 1998; monitoring wells: S – Shallow, I – Intermediate, & D – Deep.

Chemical data gathered during the course of other studies in the region also indicate that there is a strong connection between surface and ground water in the area between the canals and the river (Harvey & Sibray, 2001 & Verstraeten et al., 2001). Figure 10 shows a graph from the Steele et al. (2001) USGS Fact Sheet on the Dutch Flats area of Scotts Bluff County, which indicates the elevations of water levels from the North Platte River to the Interstate Canal and their cyclic change throughout the year based on surface water delivery and related recharge. Water level rises appear shortly after surface water is diverted to the canal. The magnitude of change that occurs in the ground water system due to surface water recharge is significant. Water levels in some monitoring wells within 1000 feet of a canal rose 10 feet during the irrigation season (Steele et al., 2001). In the area near Interstate Canal recharge was estimated, and generally agreed with the estimate of Babcock and Visher (1951), of three feet per summer (Verstraeten et al., 2001). By comparison, the local precipitation recharge in the North Platte Valley is estimated at 3 to 5 inches per year (CSD, 1984).

The same 2001 USGS study on Dutch Flats states that based upon nitrate concentrations, within one month surface water appears to replace ground water in the upper 30 feet of the alluvial aquifer within about one mile of Interstate Canal. Most of this water is less than 30 years old (Verstraeten et al., 2002). Figure 11 illustrates the age of ground water found along a transect of monitoring wells running south to north across the North Platte Valley in the Dutch Flats study area. Consequently, most of the ground water in the alluvium is water originally diverted from the North Platte River that is seeping from canals and irrigated lands. It is reasonable to expect similarly aged ground water in most areas of the North Platte Valley where surface water is applied or transported through ground water areas, which indicates the ground water to be the result of leakage from recent surface water irrigation diversions. The majority of recharge within the valley comes from water that percolates down from the canals and fields. When and where irrigation recharge water is available, the concentration of pollutants such as nitrates is diluted allowing the water to meet safe drinking water standards (Verstraeten et al., 2001). The dilution effects can be seen in Figure 12, as the water level rises due to canal leakage the contaminant concentration decreases.

Though the canal system was not designed to set up a water reuse system, that is in fact what developed. One person's waste becomes the next person's supply. Return flow from water diverted by Interstate Canal in eastern Wyoming becomes a major source of the supply for the Tri-State Canal. In turn, return flow from the Tri-State Canal provides water for other canals downstream, such as the Alliance, Chimney Rock, Browns Creek and Beerline Canals. Even ground water wells in the alluvium are dependent upon the yearly supply of ground water recharge from the surface water irrigation system. Thus, water originally diverted in Wyoming is diverted repeatedly until the final returns flow into Lake McConaughy at Lewellen. As a result, a decrease in return flows at the upstream end of the system will result in a decreased water supply for downstream water rights and alluvial ground water wells.

Ground Water Levels



Canals seepage raises ground water levels about 10 feet above seasonal low water levels near the canals.

From The Dutch Flats Report USGS-NPNRD; USGS Fact Sheet 074-01, September 2001.

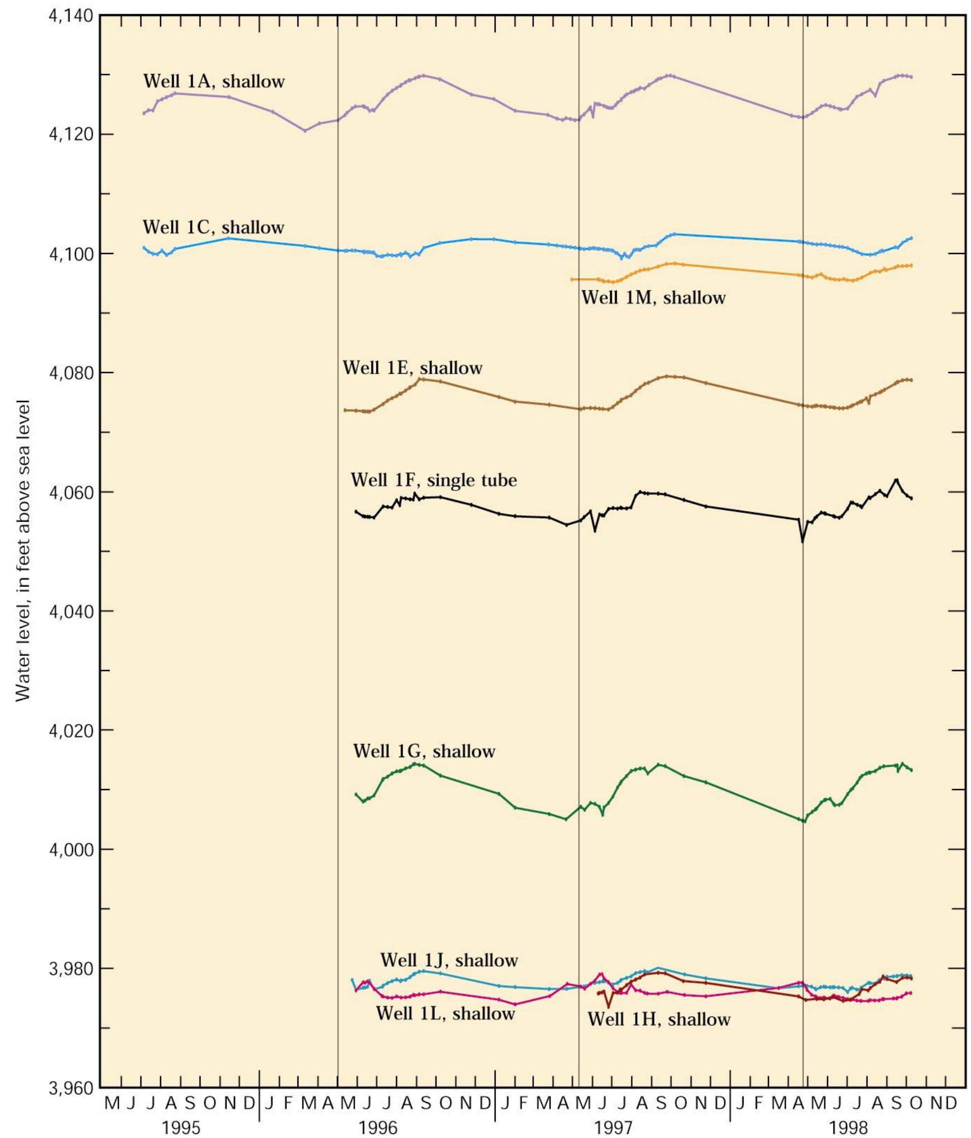


Figure 10: Water Level change looking north from the North Platte River.

Age of Ground Water

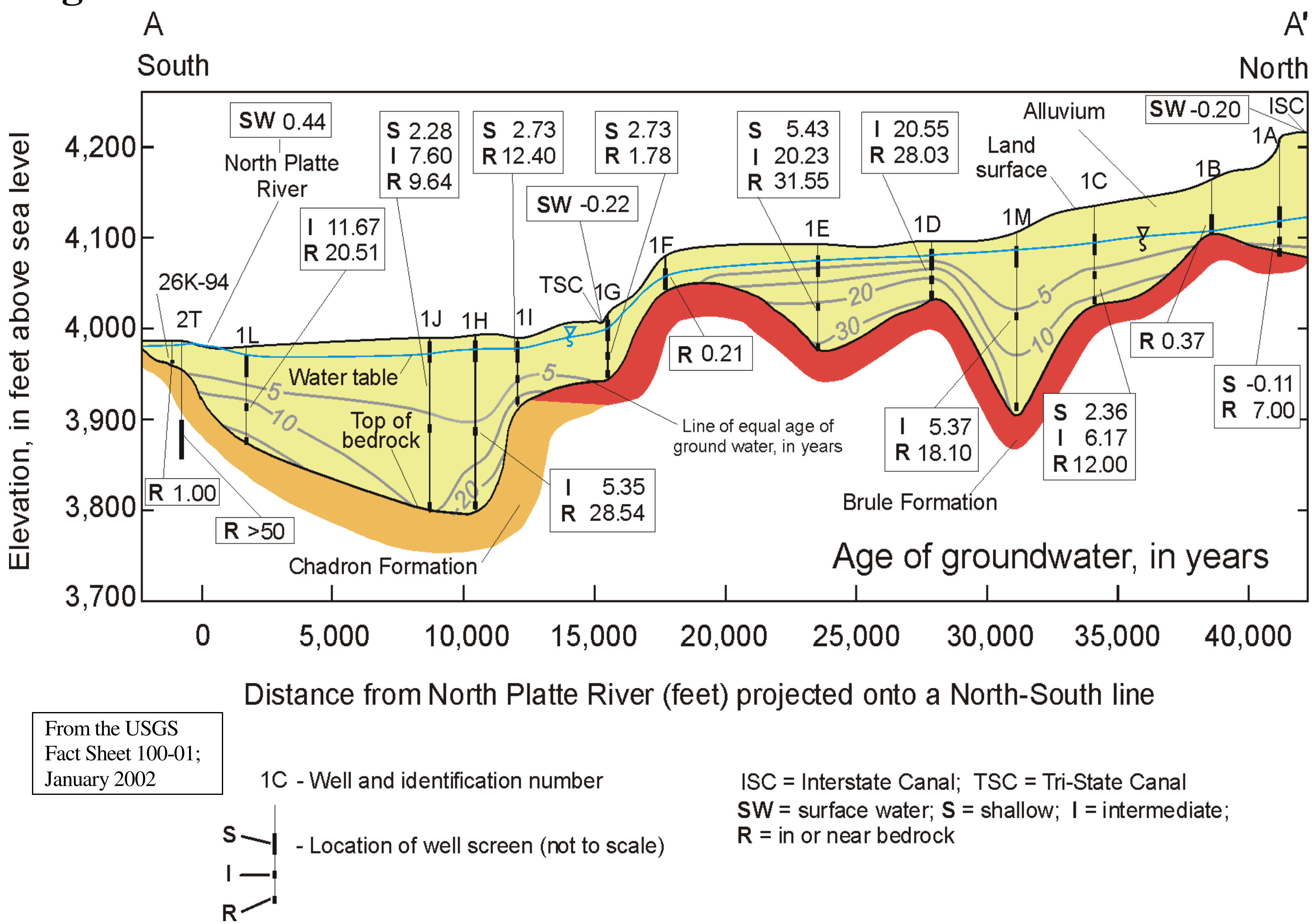


Figure 11: Ground Water in alluvial aquifer < 30 years old, overall mean age is 8.8 years. The numbers in the boxes above are the age of the water in years.

Canal Water affects Ground Water

Well 2A

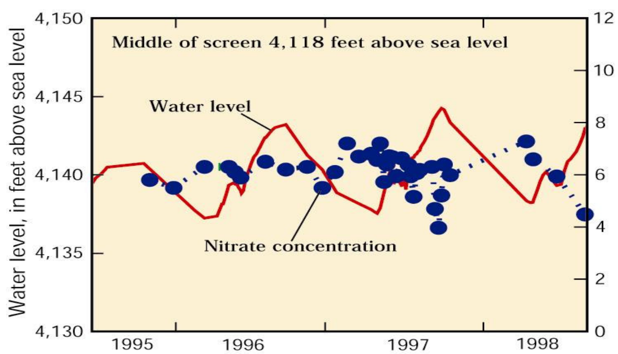
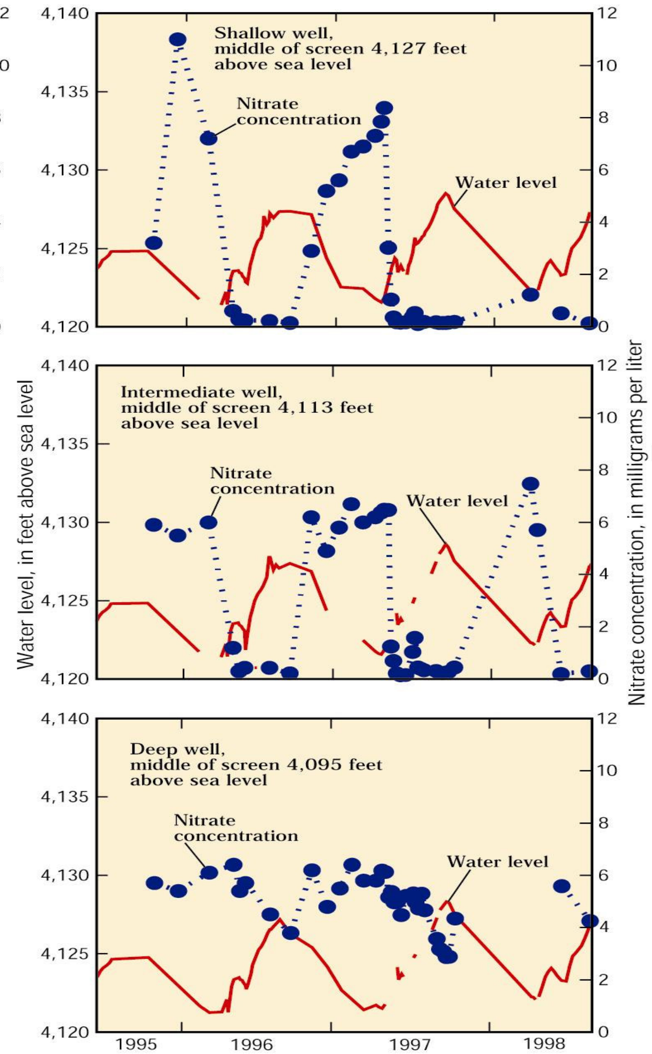


Figure 3. Variation of nitrate concentrations and water levels in monitoring wells 2A and 2B, Dutch Flats area, western Nebraska, July 1995 through September 1998.

Well nest 2B



From The Dutch Flats Report
USGS-NPNRD; USGS Fact Sheet 074-01,
September 2001

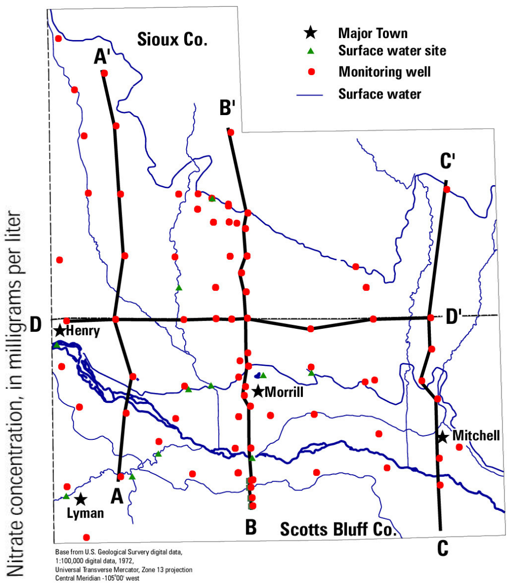


Figure 12: Leakage from canals locally causes decreases in nitrate and uranium in shallow ground water. As the water level rises due to increased canal leakage the contaminant concentration decreases.

Conflicts - Causes

Surface Water Appropriators/Ground Water Users

Figure 13 shows the 273 surface water appropriations filed in the offices of the DNR by their priority date and use as well as the corresponding number of current permitted acres. The majority of the irrigation from natural stream flow rights have priority dates older than 1920, with the oldest being 1882. The majority of the storage rights for dams within the NPNRD have priority dates after 1960. These two uses added together account for 77 percent of the 273 total appropriations in the NPNRD. The other uses have been added over time as the DNR had a larger variety of applications and the statutes changed to accommodate these uses.

Figure 14 shows the year-by-year progression of registered irrigation wells as they were completed in each study area of the NPNRD. Whereas the majority of the development of surface water appropriations occurred in the late 19^{th} and early 20^{th} centuries, ground water well development did not really get started until the late 1950's with development intensifying in the 1970's.

Currently in this section of the North Platte River, regulation of surface water rights is a yearly occurrence. The only time rights are not regulated has been in flood years, the most recent example being the early 1980's. Since 1993, the North Platte River above Lake McConaughy has been closed to new surface water appropriations because there is an insufficient supply of water to meet the demands of any additional appropriations. Once a stream is over appropriated any further depletion of stream flow would cause more surface water appropriators to be closed in any given year resulting in increased conflict.

Today, there is increasing concern over an apparent decrease in irrigation return flows supplying the tributary streams and recharging the ground water aquifers. In response DNR completed a statistical analysis of the flows in the NPNRD and factors that might impact those flows (Appendix II). According to the statistical analysis, generally the streams along the north side of the river, as well as flows at the Lewellen gage, show a negative slope in a trend analysis of their total annual flow from 1961 to 2002. Tri-State Canal has shown a decreasing trend in diversions from tributaries and an increasing trend in diversions from the North Platte River. This could be due to the fact that there is less water available in the tributaries for Tri-State to divert.

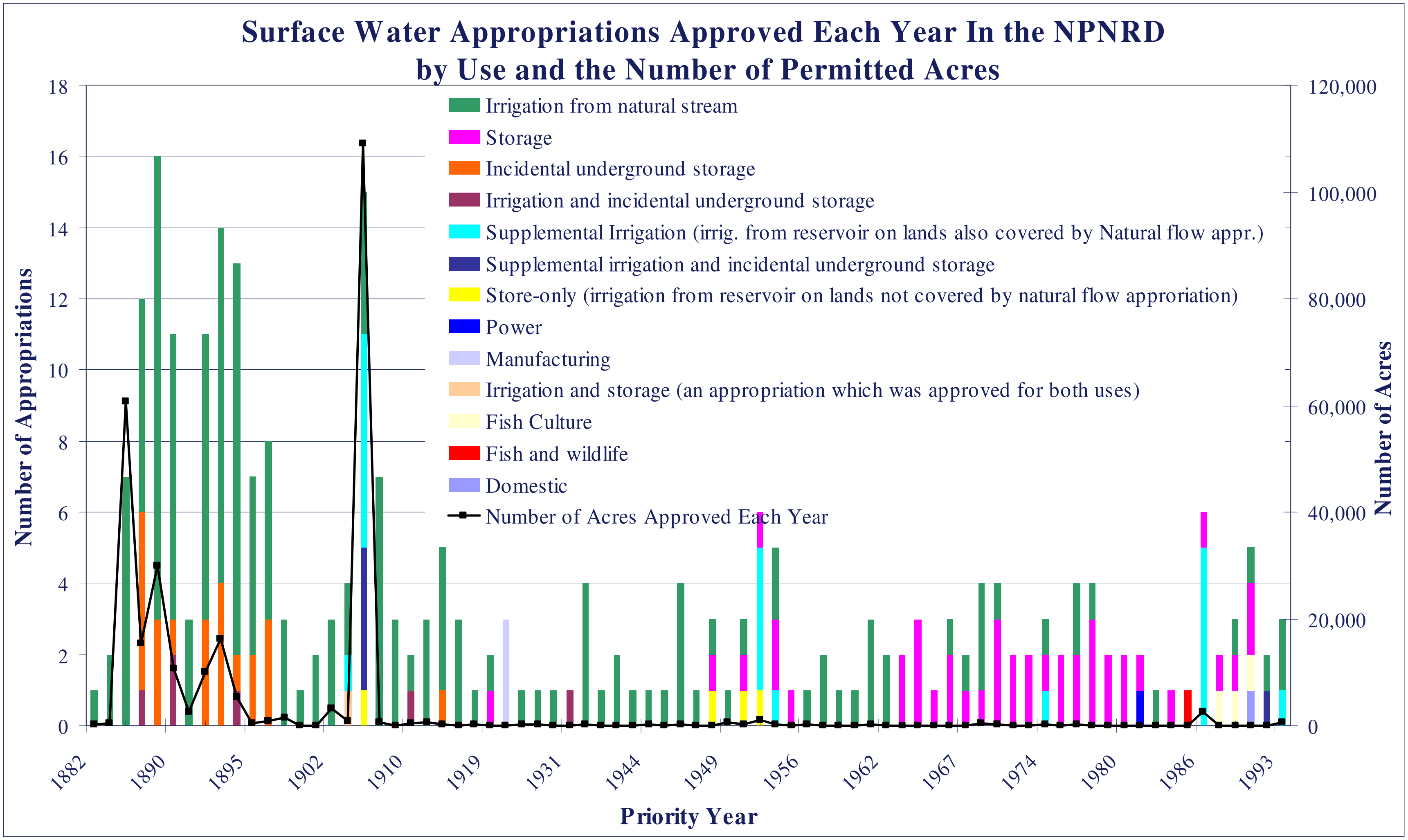


Figure 13: Surface water appropriations filed in the offices of the DNR shown by their priority date and use. On the right side axis is the number of current acres represented by the line on this graph.

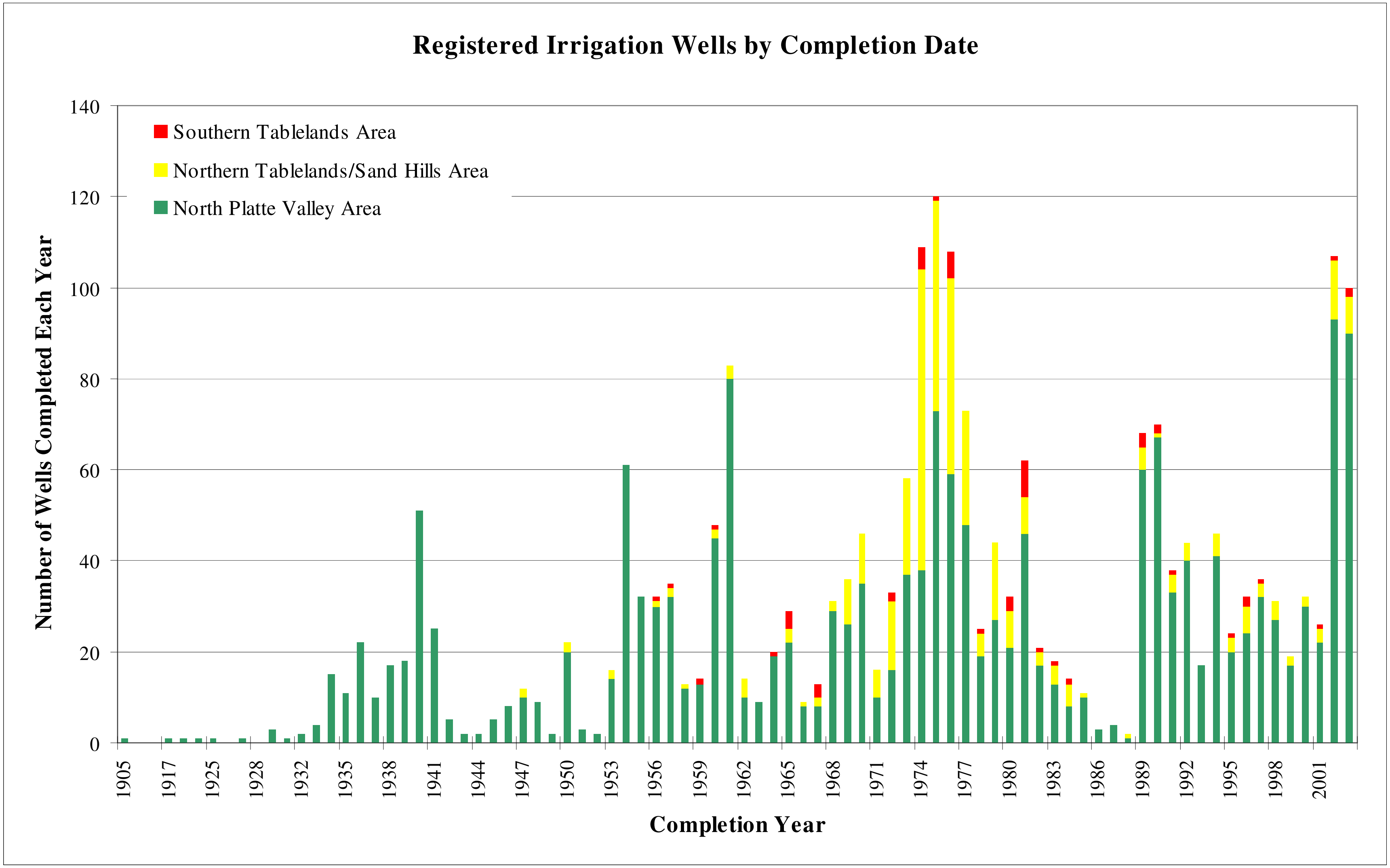


Figure 14: Year-by-year progression of irrigation wells as they were completed in each study area of the North Platte Natural Resources District.

The statistical analysis examines several possible causes for the declines in tributary flows. Possible causes include a decrease in precipitation, the outflows from Guernsey Reservoir, and the diversions of Interstate Canal, or an increase in surface water irrigated acres and ground water wells. The number of surface water irrigated acres showed a significant decrease over time; therefore, it is unlikely that increased consumptive use from surface water irrigated acres is a cause for decreases in return flows. There was however a significant increase in the number of irrigation wells. Unfortunately there are no good data describing the number of acres irrigated with ground water on a year by year basis. Therefore, the number of registered irrigation wells was used as an index of the amount of ground water irrigation. The step-wise regression analysis found several significant factors affecting stream flows. Variances in outflows from Guernsey Reservoir in Wyoming explained 91% of the annual variation in the flow at Lewellen (App. II, Table 4). Approximately 74% of the annual variation of the tributary streams (return flows) on the north side of the river can be explained by the diversions into Interstate and Tri-State Canals. Annual changes in precipitation account for only 7.1% of the variation in total tributary flow. The numbers of irrigation wells were not statistically significant factors in the regression analysis. There are several reasons why the number of wells might not emerge as a significant factor. First, the number of active wells every year does not directly correlate with the actual amount of water pumped by those wells on a year by year basis. Second, the volumes of water being recharged by the canals are so immense that in comparison to the consumptive use from wells it is difficult to find the effects of the ground water wells using a simple regression analysis.

Using a different statistical approach, the non-parametric Mann-Whitney U Test, the large impacts of canal diversions and precipitation on tributary flows were eliminated by choosing two time periods 1971-1982 and 1993-2001, for which statistical tests showed there was no significant difference in canal diversion and precipitation. The same statistical tests did however show a significant decrease in tributary flows in the later period. There was also a significant increase in the number of irrigation wells between these two time periods.

The regression analyses emphasize the importance of flows from reservoirs in Wyoming on the water supplies of the NPNRD. Whereas, the Mann-Whitney U Test indicates that wells are very likely having an impact on the tributary flows.

Ground water wells allow more acres to be irrigated as compared to the lands historically irrigated with surface water alone and allow for increased delivery of water to existing surface water acres during times when surface water is in short supply. The number of depletive wells (wells that consumptively use ground water) in the North Platte River Valley study area has increased from 1 in 1905 to approximately 2989 as of October 20, 2003 (Figure 3).

In addition to wells found inside of the NPNRD, wells downstream in the SPNRD, Twin Platte Natural Resources District (TPNRD) and Central Platte Natural Resources District (CPNRD), which consumptively use ground water that is hydrologically connected to the Platte River and its tributaries, can cause injury to surface water appropriators in the NPNRD. To the extent these wells decrease the surface flows of the Platte River downstream from the NPNRD they decrease the natural flow available to senior surface water rights. When natural flow is insufficient to meet the senior surface water rights downstream, the DNR is called upon to shut off junior rights upstream in the NPNRD, causing injury to surface water appropriators in the NPNRD.

Other State Agreements

As the result of a Cooperative Agreement signed by the states of Nebraska, Wyoming, Colorado and the U.S. Department of Interior, the State is currently involved in negotiations that could result in the implementation of an Endangered Species Recovery Implementation Program for the Platte River. An important component of this Program is the requirement that depletions to river flow caused by uses begun on or after July 1, 1997, that would adversely affect endangered species target flows be prohibited or offset with replacements. If Nebraska eventually agrees to implement the Recovery Program, an integrated management plan with the NPNRD will be required. Therefore, any new uses of ground water that deplete stream flow needed to satisfy the endangered species target flows are likely in the foreseeable future to be a cause for conflict.

III. Northern Tablelands – Sand Hills Area

Hydrogeology - Extent of the Area Affected

The composition of the aquifer in this study area trends from predominantly the Arikaree Group in the west to a mix of Arikaree and Ogallala Group near the center to predominantly the Ogallala Group in the east. On the ground water regions map (Figure 7 App. III) this area consists of two distinct regions, the Northern Panhandle Tablelands and the Sand Hills. In this study the regions were combined to reflect the fact that ground water in the Northern Panhandle Tablelands flows east into the Sand Hills toward Blue Creek and the North Platte River without any major barrier such as the low conductivity material found in the Brule Formation. Even though in terms of hydrologically connected ground water and surface water, these areas are considered one, it is important to remember that there are many characteristics which still distinguish the two regions.

The Arikaree Group, which is predominant in the Tablelands region, consists mostly of very fine to fine-grained and some medium-grained sandstone. These sandstone beds can yield moderately large amounts of water to wells that penetrate a saturated thickness of more than 100 feet in the tablelands of Sioux and Box Butte Counties (Wenzel et al., 1946). According to the 1993 NPNRD GWMP, the saturated thickness of the aquifer ranges from less than 100 feet to 500 feet. This results in a highly variable total amount of ground water in storage, ranging from 0 to 60 feet. 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 (Olsson Associates, 1993). Generally hydraulic conductivity and transmissivity in the Arikaree is lower than the same hydraulic properties of the Ogallala Group.

The Sand Hills portion of this area occurs mainly in northeastern Morrill and northern Garden Counties. A significant ground water resource is contained in this area. In this region the main aquifer is the Ogallala Group and the overlying Quaternary sand deposits. The Quaternary sand deposits are hydrologically important due to their ability to absorb precipitation and transmit it downward to the underlying Ogallala deposits. Because these sand deposits reach to the land surface, most precipitation infiltrates into the soil and overland runoff is greatly reduced. The Ogallala Group consists of gravelly sand, sand, siltstones and clay. The Ogallala has high hydraulic conductivity and specific yield, with transmissivity values ranging from less than 50,000 to 100,000 gallons per day per foot (Olsson Associates, 1993). The Ogallala Group will yield water to wells more readily than an equivalent thickness of Arikaree or Brule. In places large yields can be obtained from wells of moderate depth tapping the Quaternary sands, while elsewhere large yields can be obtained from deeper wells tapping the Ogallala. The depth to water in this area can vary from zero to more than 300 feet below the land surface, which is mainly a result of the topography of the sand dunes. The saturated thickness of the aquifer ranges from 100 to more than 500 feet, with most of the area having a thickness greater than 300 feet and an estimated total supply of water between 40 and 60 feet in the western half and over 60 feet in the eastern half (Olsson Associates, 1993). This area represents a potential source for future development.

Unlike the North Platte Valley, surface water is not transported into this area by a network of canals from large storage reservoirs located upstream. The source of water is local precipitation and underflow of ground water primarily from the north and west. Local recharge rates from precipitation range from 0.5” to 0.8” per year in the Northern Tablelands (CSD, 1984) to 2” to 2.5” per year in the Sand Hills (COHYST, 2003). The difference in recharge rates can be mostly attributed to the sandy soils of the Sand Hills.

The ground water contour map (Figure 9, App. III) shows that ground water flows in a variety of directions due to the ground water divide through this area. The map shows that most of the ground water in the Sand Hills flows south and east toward Blue Creek and toward the North Platte River. The ground water also flows north and east into the UNWNRD in the direction of Snake Creek and tributaries to the Niobrara River. Toward the eastern edge of the study area the ground water flows into the Twin Platte (TPNRD) and Upper Loup (ULNRD) Natural Resource Districts eventually flowing to the Platte River downstream of the NPNRD.

David L. Rus et al. (2001) tested streambed hydraulic conductivity (K) at one site on Blue Creek, out of the North Platte River flood plain. Large variability in K (<0.01 to 170 ft/day) was found at this site because of interspersed layers of silt and sand. Though the silt layers could impede the ground and surface water connection at this site, the extent of these layers is not well known, nor would they impede any horizontal flow of ground water to the creek. Stream gage data showing very constant seasonal flows and water level contour maps support the theory that Blue Creek is a predominantly ground water-fed stream. The Sand Hills Atlas (1989) also refers to Blue Creek as a predominantly ground water-fed stream.

<u>Conflicts - Causes</u>

Surface Water Appropriators/Ground Water Users

The oldest surface water rights on Blue Creek date from 1890 (Table 1 Appendix IV). In total, there are 16 surface water rights on Blue Creek and its tributaries, with 15 of them totaling 143.25 cfs and 1 storage right for 4.93 ac-ft. According to DNR registered well records, ground water wells were first completed in this area in 1910 (Figure 3), and as of October 2003, there were approximately 710 depletive wells in this study area. A historical high of 66 wells completed per year was reached in 1974 and a recent high of 73 per year in 2002 (Figure 15). A band of well development can be seen paralleling the North Platte River Valley to the north above the escarpment (Figure 5 App. III). Further west and north the area is not suitable for row crop development as can be seen from the lack of crops in the area on Figure 4 App. III. There are very few wells, even though the potential exists to develop ground water wells, and no surface water rights in the northwest portion of the study area. Outside of the NPNRD boundaries, but hydrologically connected to the ground water within the NPNRD, are approximately 1,200 active registered irrigation wells in Box Butte County (Figure 5 App. III).

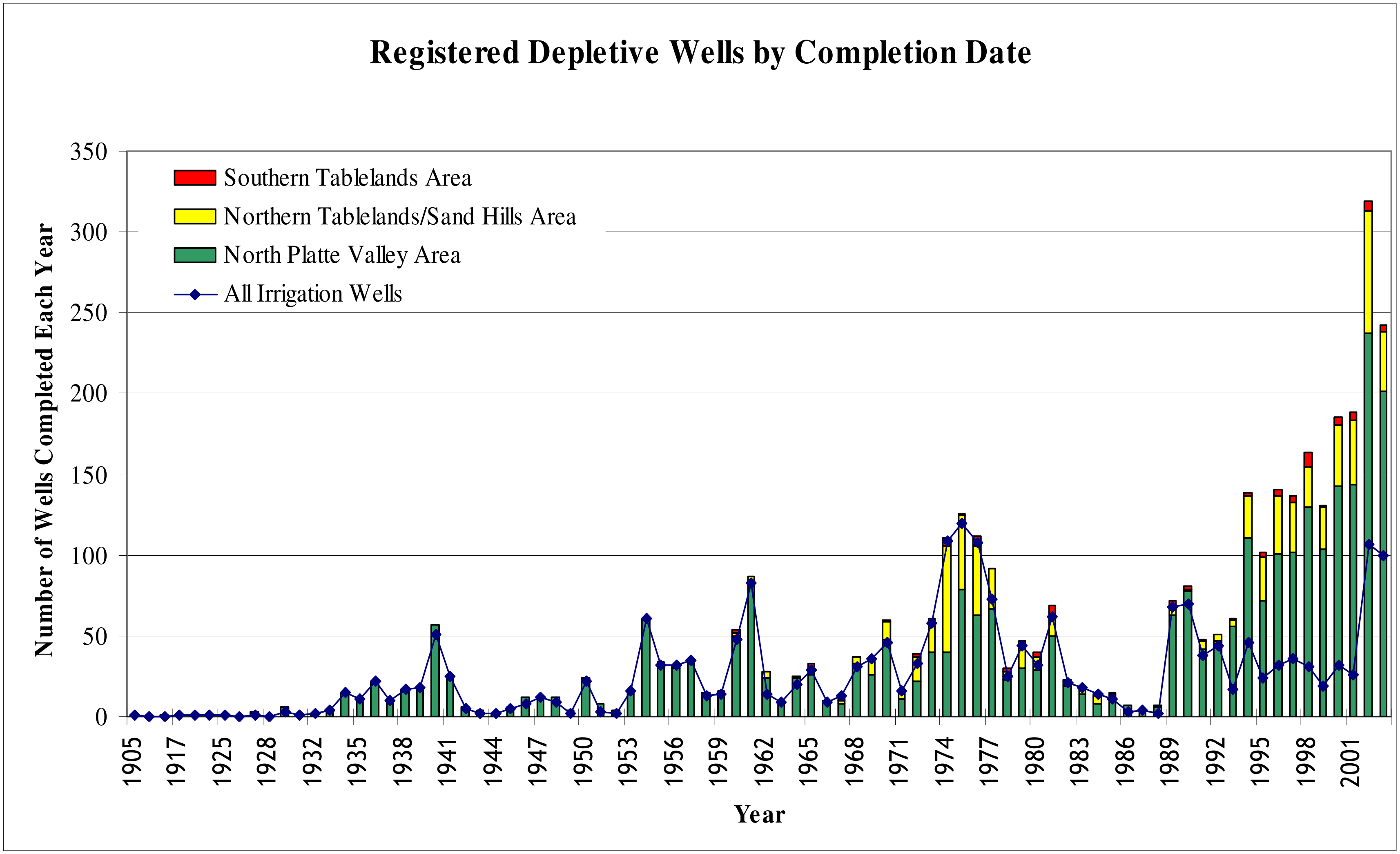


Figure 15: Depletive ground water wells listed by completion date and by study area.

A monitoring well in this study area shows a steady decline in water table elevations of approximately 12 feet since 1984 (Figure 16). On Figure 17 in the area of Box Butte County, the USGS ground water contour lines show a steep decline, +50 feet, that reaches slightly into Morrill County, and flow lines show ground water in the surface water drainage of the North Platte River to be flowing toward the depression in Box Butte County, into the UNWNRD. This is not surprising considering the large water level declines seen in the area around the City of Alliance. Continued well development in this area will ultimately impact the surface water supply of the North Platte River as well as streams in the UNWNRD.

Even though there is currently little ground water development in the far northwestern corner of this area, there is more than 60 feet of total supply in some areas (Olsson Associates, 1993) that may be attractive for development of industrial or commercial consumptive uses as other sources of ground water are regulated.

In § 46-656.06, the Legislature recognized that ground and surface water use in one NRD may have adverse effects on water supplies in another NRD, and that each NRD is expected to accept responsibility for ground water management in these areas in the same manner and to the same extent as if the conflicts were contained within their own district. In a letter dated February 26, 2003, the Department of Natural Resources made a preliminary determination that the use of hydrologically connected ground and surface water was contributing to conflicts in the UNWNRD. Similar letters stating that the use of hydrologically connected ground water and surface water was contributing to conflicts were sent to the CPNRD, TPNRD, and SPNRD. Evidence of conflicts in these various NRDs which are adjacent to or near the NPNRD must be taken into consideration in developing any joint action plan.

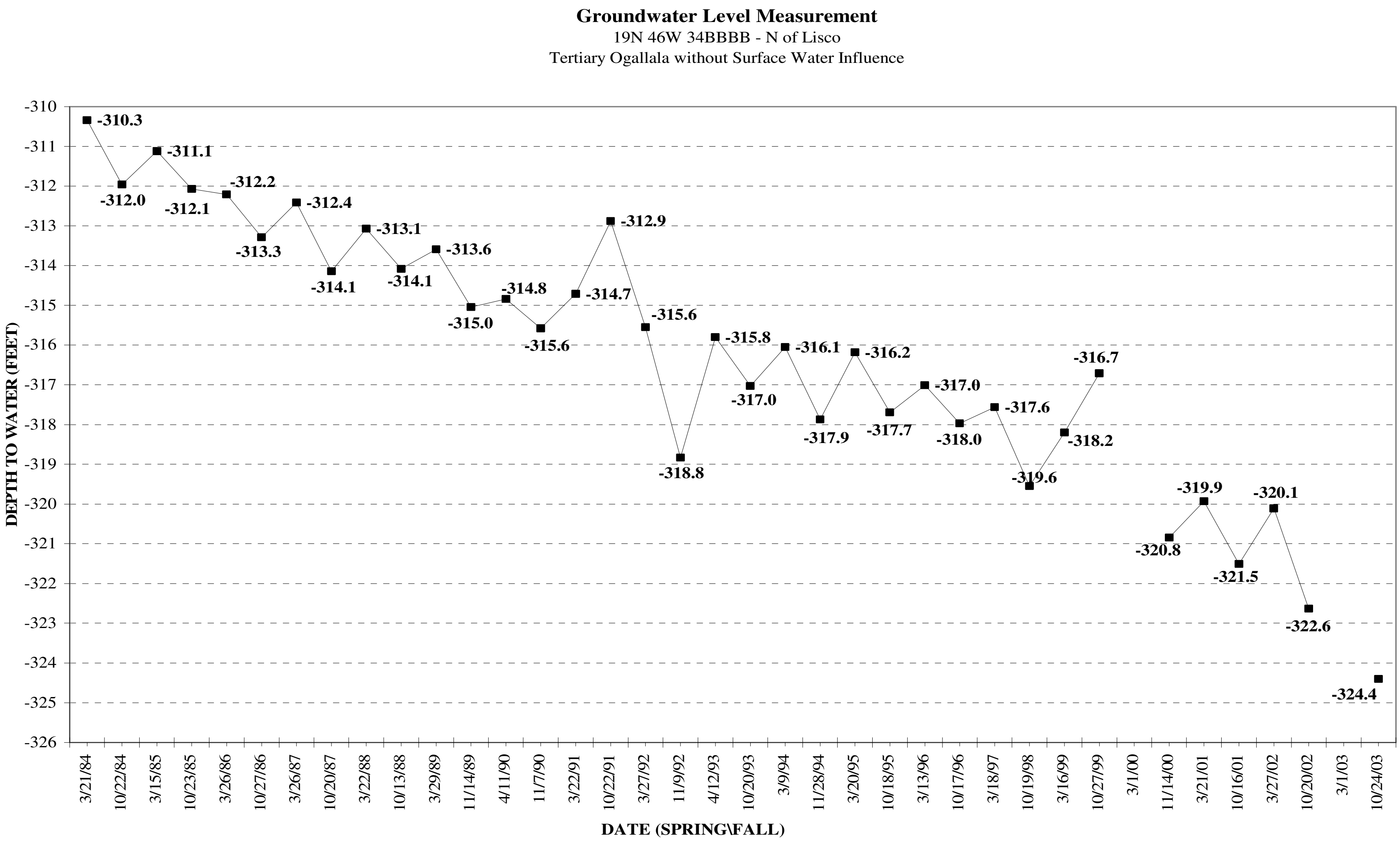


Figure 16: Monitoring well showing an approximate a 12 foot decline since 1984 when monitoring began at this site, no DNR registration number.

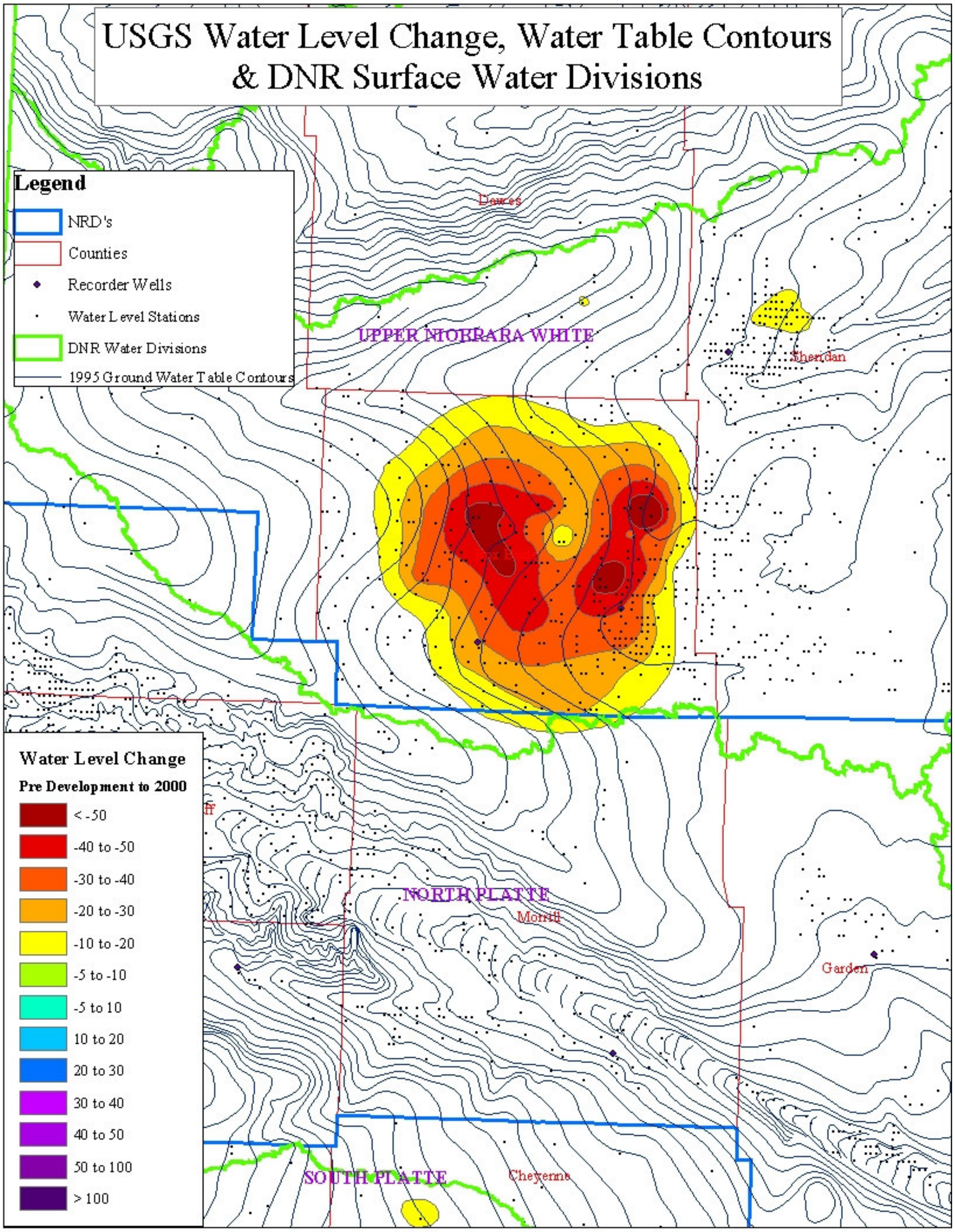


Figure 17: USGS Pre-Development to 2000 ground water level declines, 1995 water table contours & DNR surface water division boundaries, depicting the contrast between the surface water boundary and the direction of ground water flow in northern Morrill County.

Though outside the scope of this study, the question of what, if any, impacts increased numbers of depletive ground water wells might have on the many sub-irrigated meadows, wetlands and lakes in the Sand Hills area was raised by persons in the stakeholders group. Many of these lakes are a manifestation of the natural high water table and the ground water supply is critical to the existence of Sand Hills Lakes (Winter, 1986; Bleed and Flowerday, 1989). In these areas a small change in the elevation of the water table due to the consumptive use of ground water can have large impacts on the number and/or size of these lakes and wetlands. In addition the combination of a high water table, sandy soils, hydraulic conductivity and other factors create an area with high vulnerability to contamination from surface water sources (Olsson Associates, 1993). Future development in this area needs to be considered carefully to minimize any impacts not only on the quantity, but also on the quality of the ground water.

IV. Southern Tablelands Area

Hydrogeology – Extent of the Area Affected

The Southern Tableland area is underlain by the Ogallala Group, which is the most important water-bearing stratigraphic unit in this region. As described in the 1993 NPNRD GWMP, the Ogallala Group ranges from 45 to 540 feet in thickness and is composed of gravelly sand, sand, siltstones, and clay. The depth to ground water 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. Values of transmissivity range from less than 50,000 to 100,000 gpd/ft in most of the region, 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 in a narrow stretch along the southern boundary of Banner County (Olsson Associates, 1993). As mentioned previously, the Ogallala Group has a higher average permeability than the Arikaree Group and Brule Formation, meaning that ground water flows more easily through the Ogallala than the Arikaree. Influencing the direction of ground water flow in this area is a paleovalley (Figure 12 Appendix III). Ground water coming into this paleovalley is funneled toward the North Platte River.

Although this area is underlain by a fairly thick sequence of Tertiary deposits, zones of saturated permeable rock that are thick enough to yield adequate water for irrigation use occur only in localized areas. Based on information from the test holes of a previous study, only a relatively small portion of the total volume of the Ogallala sediments is saturated (Smith and Souders, 1975). Thus, the supply of ground water is limited in quantity and extent.

Generally, ground water flow is toward the North Platte River. In the westernmost portion of the study area, the ground water flows into the SPNRD from Banner County and then flows back toward the North Platte River in the paleovalley mentioned above. In Banner County the ground water also converges along the Lawrence Fork and its tributaries, ultimately reaching an area where it issues from springs and seeps, is lost to evapotranspiration or flows to stream channels, if not intercepted by pumping wells (Smith and Souders, 1975). The ground water in southern Morrill and Garden Counties flows toward the North Platte River and its tributaries.

The source of water is similar to the Northern Tablelands – Sand Hills area in that the source is local precipitation. The local recharge rate is low ranging from 0.2" to 0.8" per year (CSD, 1984).

This region is relatively flat with incised drainages. Currently, the majority of agriculture in the area is dry land wheat fallow rotation (Figure 4 App. III).

Conflicts – Causes

Surface Water Appropriators/Ground Water Users

Within the Lawrence Fork drainage, seven surface water rights exist, six direct flow diversions totaling 4.99 cfs and one storage right for 25.05 ac-ft. The oldest surface water rights on Lawrence Creek date from 1891 (Table 1 Appendix IV). Surface water rights are also found on Deep Holes Creek and Cedar Creek, which have contributing drainage areas originating in the southern tablelands of Morrill and Garden Counties.

According to registered well records, ground water wells were first completed in this area in 1956 (Figures 3 & 15). As of October 2003, there were 93 depletive wells in this area (Figure 3).

Whatever ground water there is to be found in this area moves toward the North Platte River or its tributaries and the stream network is tributary to the North Platte River. However, the aquifer is limited in quantity and extent, the depth to ground water is large and the recharge rate is small. Ground water level measurements show declines in some areas (Figure 18) and slight increases in other areas (Figure 19). The hydrologic properties indicate a connection between this study area and the North Platte River; however, the degree of connection is not well understood given the available data. Generally, it can be said that this study area is less directly connected to the North Platte River than the Northern Tablelands – Sand Hills study area. Use of the ground water supplies could impact the water table and consumptive use of ground water in this region would, however minimally, affect the surface water appropriators on the North Platte River or its tributaries.

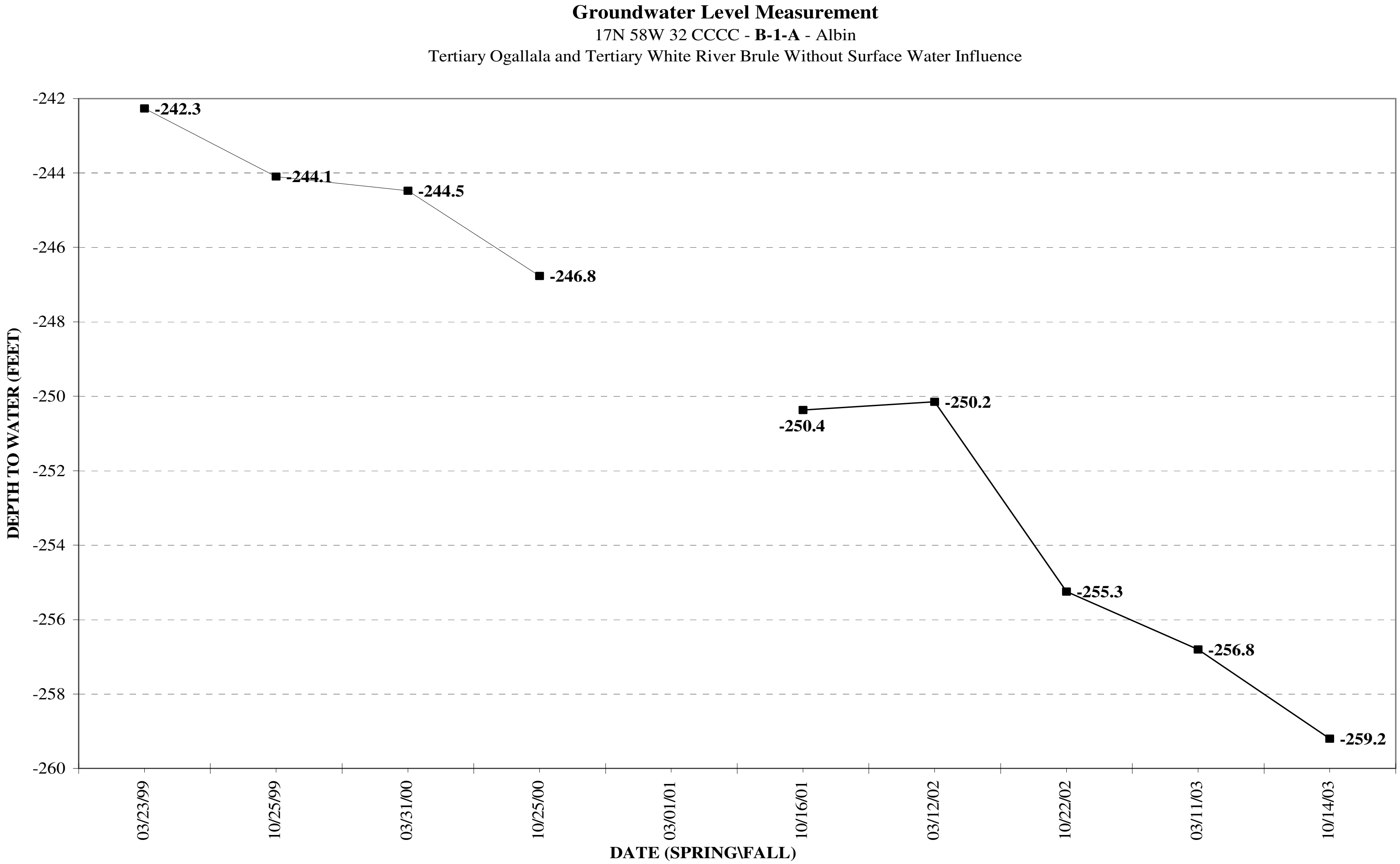


Figure 18: Ground Water level measurement in a well with DNR Registration number G-097606.

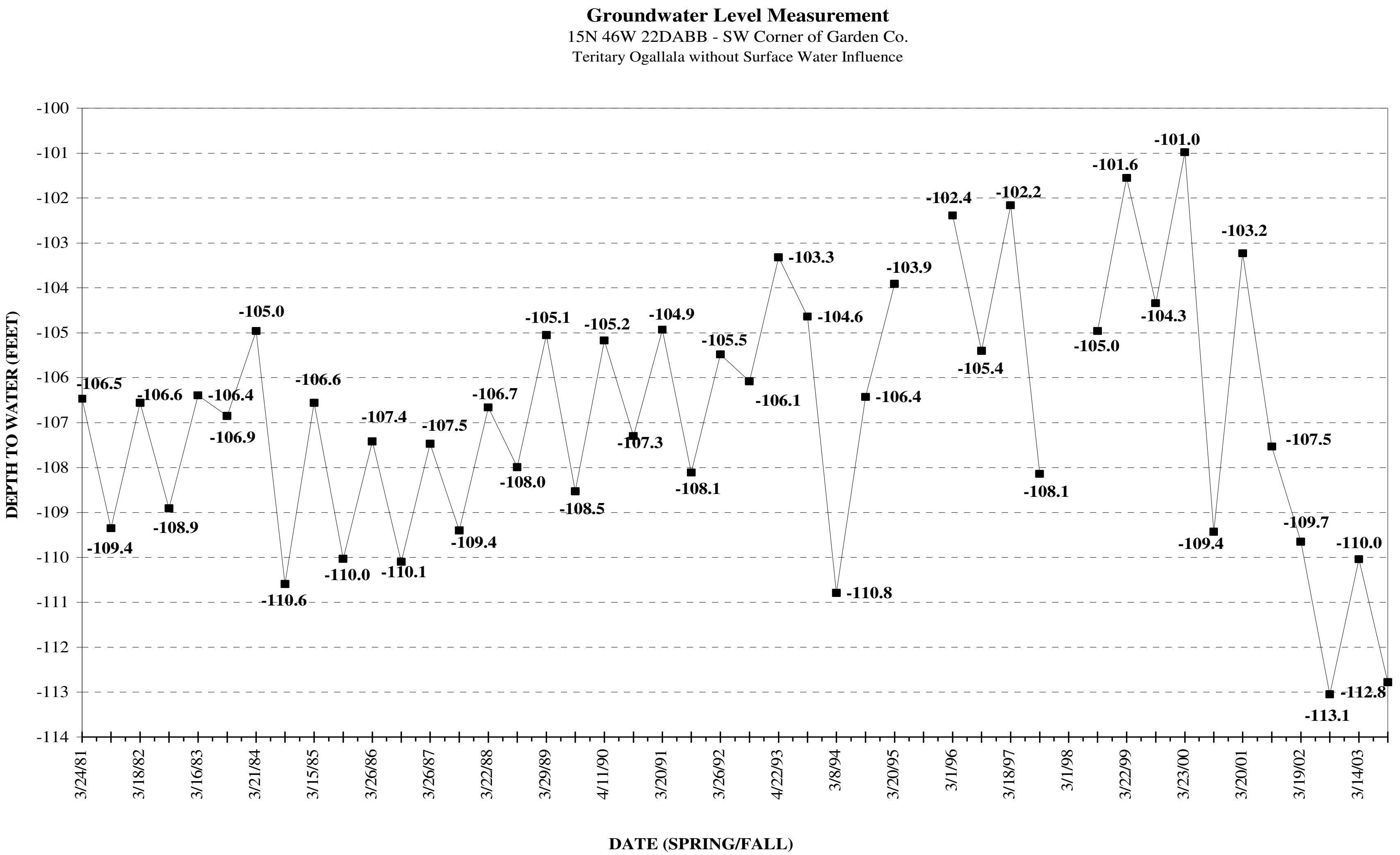


Figure 19: Ground water level measurement in a well with DNR registration number G-042220.

V. Other Considerations

Meetings with the NPNRD Board of Directors and the stakeholders group brought forward some questions which apply to the entire NPNRD study area and need to be addressed. Concerns were raised over changes in the intensity of precipitation since the 1970's. Discussions with Al Dutcher, Nebraska State Climatologist, suggest that given the current data available, any analysis would be extremely difficult, if not impossible, and very suspect as to reliability. Studies of this type have been done in the South and have shown increased runoff with increased precipitation intensity on clay soils. However, Mr. Dutcher stated that the highly permeable soil types in the NPNRD would not likely result in increased runoff and reduced infiltration even if precipitation intensity had increased.

Group members also questioned whether the change from a predominantly gravity irrigated system to sprinklers and center pivots would affect stream flows. The DNR spoke with Dean Eisenhauer, Ph.D, UNL Biosystems Engineering, who stated that the switch by itself would not result in increased consumptive use of water; however, increased numbers of acres and increased number of plants in a field, resulting from a more efficient use of water would increase the consumptive use. Basically, any increase in yield would result in increased consumptive use. Other conservation measures such as no-till, terraces, reuse pits, etc. which would result in an increased yield would also increase the consumptive use. At this time there is no good data available to test this hypothesis. The question of the effect of cropping pattern changes was also raised. Dean Eisenhauer stated that changes in cropping patterns could produce a small difference in consumptive use, but that there are currently no good data to make a conclusion one way or another. Further study would be required to understand the impact these practices are having on stream flow.

During periods of drought more conflicts naturally occur because demand for water increases while the overall supply is diminished. However, because of the nature of ground water, by the time a drought is occurring it is much too late to alter the management of ground water to address the shortage of water. Therefore, in periods of plenty, the ground water as well as the surface water system needs to be managed to plan for the periods of drought. Note on the various water level figures throughout this report the effect of the recent drought. The fall 2002 water level measurement in Figure 5 is 4 feet lower than any previously recorded low. Figure 6 shows a steeper level of decline in the period from 1999 to 2003 than previously recorded. Figure 19 shows no winter recovery in water levels between the fall of 2001 and spring 2002.

An indication of increasing demand and limited supply in this period of drought comes from the general public. At three NPNRD board meetings during 2003, citizens voiced their concerns regarding wells and surface water features going dry. Also during 2003, the NPNRD recorded 21 complaints on wells going dry as well as 3 complaints concerning a shortage of surface water. In 2002, though the complaints were not logged, both the NPNRD and the DNR received numerous calls from the public stating that domestic wells and some irrigation wells were pumping air.

VI. Summary

The **North Platte Valley** study area has a very close connection between surface water and ground water due to the hydrogeology of the area and the presence of many large and small irrigation canals. The surface water diverted by the canals and leaked into the ground is the major source of water for recharging the ground water supply on an annual basis. Without this annual recharge most now perennial tributaries would return to the pre-development state and be dry most of the year. Ground water irrigation wells draw on this supply to irrigate land without any surface water supply and to supplement acres served by surface water irrigation. Without the canal leakage and deep percolation from surface water irrigation, the large supply of ground water would not be available to the ground water wells. Return flows, on which downstream surface water appropriators depend, would also disappear. Statistical analyses of return flows show general declining trends between 1961 and 2002. Increased ground water use is one cause of these declines.

In most years the DNR must reduce diversions on the North Platte River because of insufficient stream flow. In 1993, the DNR stopped issuing new surface water rights because of insufficient unappropriated water. Any new depletion to the water supply by surface or ground water uses would cause increased injury to existing surface water appropriators. This constitutes one conflict between surface water appropriators and ground water users. In addition, as canal diversions decrease due to a decrease in supplies, recharge to the ground water supply for wells in the area will also decrease causing further conflict.

The **Northern Tablelands – Sand Hills** study area has a large supply of ground water, due mainly to the recharge in the Sand Hills area. Surface water features such as the ground water-fed Sand Hill lakes and Blue Creek are driven by ground water supplies. Most of the ground water in this study area flows toward the North Platte River and its tributaries downstream of Broadwater where the Brule Formation is overlain by the Ogallala Group, which, with the overlying Quaternary Sands, becomes the main aquifer. Essentially, this study area feeds the baseflow of the North Platte River from the north side, downstream of Broadwater.

Because in this study area ground water is hydrologically connected to the North Platte River, any new depletion to the water supply will cause injury to existing surface water appropriators on the North Platte River, as well as on Blue Creek. Statistical analysis on Blue Creek shows a significant declining trend in average annual flows from 1961 to 2002. Blue Creek and other North Platte River tributaries in this study area are also subject to the 1993 DNR determination of over appropriation. The number of new depletive ground water wells has increased since 1993 and there is potential for further development of depletive wells in this study area. This constitutes a conflict between surface water appropriators and ground water users.

Within the bounds of the **Southern Tablelands** study area the surface water supply is at a minimum. Yet, the water table contour map and geologic evidence show that ground water does flow to the North Platte River and its tributaries; particularly through the paleovalley that runs to the North Platte River. However, the quantity and extent of ground water supplies and the geology in this study area suggest that this area has the least direct hydrologic connection to the North Platte River, which over time are likely to deplete flows in the North Platte River.

The number of new depletive ground water wells has in this area increased since 1993. The potential for further development is limited within the NPNRD; however, in the area of the paleovalley in the SPNRD, the potential does exist for the increased development of ground water supplies.

Preliminary Findings of the Director

In most years numerous surface water appropriations in the North Platte Natural Resources District are regulated or shut off because of insufficient flow in the North Platte River and its tributaries.

In 1993, the Department of Water Resources placed a moratorium on issuing new surface water permits in the North Platte River Basin because of insufficient unappropriated water.

The ground water aquifers throughout the North Platte Natural Resources District are hydrologically connected to the North Platte River and its tributaries.

Current uses of that hydrologically connected ground water are causing depletions to stream flows of the North Platte River and/or its tributaries and any increase in consumptive use of water in these aquifers will cause further depletions to stream flows of the North Platte River and/or its tributaries.

Any such increased depletion will further decrease already over appropriated stream flows and cause additional conflicts between surface water appropriators and ground water users, both within the North Platte Natural Resources District and downstream of the District.

During the study conducted by the Department, I, as Director, considered all relevant portions of the NPNRD Ground Water Management Plan developed by the District pursuant to § 46-656.12 to § 46.656.16 of the Nebraska Revised Statutes and have determined that the use of hydrologically connected ground water and surface water resources in the NPNRD, excluding the area along Pumpkin Creek because it is already within an integrated management area, is contributing to and in the reasonably foreseeable future is likely to continue to contribute to conflicts between ground water users and surface water appropriators and that conflicts between ground water users and surface water appropriators could be eliminated or reduced through the exercise of the authority of subsection (5) of § 46-656.28 of the Nebraska Revised Statutes.

February 27, 2004

Roger K. Patterson
Director, Department of Natural Resources

Bibliography

Babcock, H. M. and F. N. Visher. 1951. Ground-water Conditions in the Dutch Flats Area Scotts Bluff and Sioux Counties Nebraska With a Section on the Chemical Quality of the Ground Water. Geological Survey Circular 126. U. S. Geological Survey. Washington, D. C.

Bleed, A. and Flowerday, C. Eds. 1989. An Atlas of the Sand Hills. Resource Atlas No. 5. Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

Bleed, A. 2000. The Source of Water and the Surface and Ground Water System of the North Platte and Platte Rivers. Nebraska Department of Water Resources. Lincoln, Nebraska.

Channel, C.P. 1901. Third Biennial report of the State Engineer, Secretary of the State Board of Irrigation to the Governor of Nebraska 1899-1900. Hunter Woodruff Printing Company. Lincoln, Nebraska.

COHYST. 2003. Personal communication Jim Cannia.

Conservation and Survey Division (CSD), Institute of Agriculture and Natural Resources University of Nebraska Lincoln. 1984. Handbook on the Preparation of Ground water Management Plans. Nebraska Association of Resources Districts, Lincoln, Nebraska.

Crist, M. A. and Lowry, M. E. 1972.Ground-Water Resources of Natrona County, Wyoming. Geological Survey Water-Supply Paper 1897. U.S. Government Printing Office. Washington, D.C.

Darton, N. H. 1899. Preliminary Report on the Geology and Water Resrouces of Nebraska West of the One Hundred and Third Meridian. Nineteenth Annual Report of the U. S. Geological Survey 1897-1899. Government Printing Office. Washington, D. C. pp. 719-814.

Eschner, T.R., R.F. Hadley and K.C. Crowley. 1981 Hydrologic and Morphologic Changes in Channels of the Platte River Basin: A Historical Perspective. Open-file Report 81-1125. U. S. Geological Survey.

Fremont, Brevet Captian J.C. 1845. Report of the Exploring Expedition to the Rocky Mountains in the Year 1842 and to Oregon and North California in the years 1843 and 1844. Gales and Seaton. Washington, D.C.

Harvey, F.E. and S.S. Sibray, 2001, Delineating Ground Water Recharge From Leaking Irrigation Canals Using Water Chemistry and Isotopes, Ground Water, 39(3), p. 408-421.

Morris, D. and Babcock H.M. 1960. Geology and Ground Water Resources of Platte County, Wyoming. Geological Survey Water-Supply Paper 1490. U.S. Government Printing Office. Washington, D.C.

Nebraska Department of Water Resources. 1959-1995. Discharge Records for Streams, Canals, Pumps and Storage Reservoirs 1959-1995. Department of Water Resources. Lincoln, Nebraska.

Nebraska Department of Roads and Irrigation. Twenty-Second Biennial Report Bureau of Irrigation, Water Power and Drainage to the Governor of Nebraska 1937-1938. Nebraska Department of Administrative Services. Lincoln, Nebraska.

Olsson Associates. 1993. Revised Ground water Management Plan North Platte Natural Resources District.

United States Department of Commerce. 1973. Climatography of the United States No. 81: Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, Kentucky, 1941-1970. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC.

United States Department of Commerce. 1982. Climatography of the United States No. 81: Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, Kentucky, 1951-1980. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC.

United States Department of Commerce. 1992: Climatography of the United States No. 81: Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1961-1990. National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC.

United States Department of Commerce. 2002: Climatography of the United States No. 81: Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, Kentucky, 1971-2000. National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC.

Reed, E.C. 1969. Conservation and Survey Division. "Underground water areas – state of Nebraska".

Rapp, J. R. , F. N. Visher and R. T. Littleton. 1957. Geology and Ground-Water Resources of Goshen County Wyoming. Geological Survey Water-Supply Paper 1377. U. S. Government Printing Office. Washington. D. C.

Rus, D.L., MgGuire, V.L, Zurburchen, B.R. and Zlotnik, V.A. 2001. Vertical Profiles of Streambed Hydraulic Conductivity Determined Using Slug Tests in Central and Western Nebraska. U.S. Geological Survey Water-Resources Investigations Report 01-4212.

Smith, Frank A, and Souders, Vernon L. 1975. Groundwater Geology of Banner County, Nebraska. Nebraska Water Survey Paper Number 39. Conservation and Survey Division, Institute of Agriculture and Natural Resources, The University of Nebraska-Lincoln.

Smith, H.O. 1897. History of Irrigation in Dawson County. In. First Biennial Report of the State Board of Irrigation of the State of Nebraska for the Years 1895 and 1896. Submitted by W.R. Akers. Jacob North and Company. Lincoln, Nebraska.

Steele, G. V., Verstraeten, I. M. and Cannia, J. C. 2001. Surface-Water/Ground-Water Interaction and Implications for Ground-Water Sustainability in the Dutch Flats Area, Western Nebraska., U.S. Geological Survey Fact Sheet 074-01.

Verstraeten, I.M., Steele, G.V., Cannia, J.C., Hitch, D.E., Scripter, K.G., Bohlke, J.K., Kraemer, T.F., and Stanton, J.S., 2001, Interaction of Surface Water and Ground Water in the Dutch Flats Area, Western Nebraska: 1995-1999, U.S. Geological Survey Water-Resources Investigations Report 01-4070, 56 p.

Verstraeten, I.M., Bohlke, J.K., Kraemer, T.F.,and Cannia, J., 2002, Use of environmental tracers and isotopes to evaluate sources of water, nitrate, and uranium in an irrigated alluvial valley, Nebraska: U.S. Geological Survey Fact Sheet 100-01.

Verstraeten, I.M., Sibray, S.S, Cannia, J.C. and Tanner, D.Q. 1995. Reconnaissance of Ground-Water Quality in the North Platte Natural Resources District, Western Nebraska, June-July 1991. U.S. Geological Survey Water-Resources Investigations Report 94-4057.

Wenzel, L.K., R. C. Cady, and H. A. Waite. 1946. Geology and Ground-Water Resources of Scotts Bluff County, Nebraska. U. S. Geological Survey Water-Supply Paper 943. U. S. Government Printing Office. Washington. D. C.

Willis, Robert H. 1910. Report of R. H. Willis, Under Secretary, Water Division No. 1. The Eighth Biennial Report of the State Board of Irrigation to the Governor of Nebraska. Submitted by E. C. Simmons. Claffin Printing Co. University Place, Nebraska.

Willis, Robert H. 1930. Stream Flow Control. In Irrigation in Nebraska Historical and Informational Articles. Assembled by Nebraska Division of Administration. 1950-1951. pp. 33-34. Mimeograph.

Winter, T.C. 1986. Effect of ground-water recharge on configuration of the water table beneath sand dune and on seepage in lakes in the Sandhills of Nebraska, U.S.A. Journal of Hydrology, no. 86, p. 221-237.