Hydrologic Trends and Correlations in the Republican River Basin in Nebraska

Prepared for:

Prepared by:

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June 2006

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The Nebraska Department of
Natural Resources

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1. Introduction

Since the implementation of the Republican River Compact Settlement, water accounting analyses show groundwater pumping is causing additional streamflow depletions. As a result, the State of Nebraska has imposed some restrictions on groundwater pumping and may need to apply additional ones to address low streamflow conditions. In an attempt to better understand the trends in streamflows and groundwater levels in Nebraska, HDR Engineering, Inc. has conducted a study of hydrologic data with the purposes of defining surface water and groundwater trends and correlating them. The goals of the study are to provide documentation of trends in groundwater levels and streamflow and to correlate these trends so that better estimates future streamflow can be made. In other words, the study is intended to provide a qualitative assessment of connectivity of streams and aquifer in the Republican River Basin in Nebraska, not a quantative assessment of determining the exact responses of streamflow to groundwater pumpage. The study was essentially restricted to Nebraska.

2. Data Sets

2.1 Groundwater Levels

The U.S. Geological Survey's (USGS) National Water Information System (NWIS) was the source for well records and groundwater level data. This data set is very comprehensive in coverage and in historic and current content. Certainly, there are additional data in project files and in local offices that would be of great value for local studies. However, for purposes of this regional study, USGS data are considered to be adequate. Figure 1 shows the locations of the wells with 2005 water level measurements; and the ones with historic data for, at least, the last 15 years to draw water level hydrographs. Table 1 lists the wells that were selected for use in the trend analysis.

2.2 Streamflow

The sources of streamflow data included the USGS and Nebraska Department of Natural Resources (DNR). With the great interest in current conditions, some of the daily streamflow

values were preliminary, i.e., they had not received final internal review. Also, in some cases, HDR estimated values for relatively short periods that were missing, usually for ice conditions and equipment failures. Exceptions are for the streamflow gaging stations below Swanson Lake and Enders Reservoir which were only operated during the irrigation season since Sept 30, 1993. Also, streamflow and baseflow were estimated for ungaged stream segments between the inflow and outflow gages of Swanson Lake and Harlan County Lake for basin-wide assessments.

The location of these gaging stations are shown in Figure 2 and listed in Table 2.

The streamflow was separated into a baseflow and runoff components using the method adopted the groundwater consultants who worked on the Settlement. The analyses for the Settlement extended from the beginning of the record to September 30, 2000. Using Water Year 2001-2005 daily data and this method, the separation of streamflow records was extended to September 30, 2005.

2.3 Canal Diversions

Daily diversion data for the major canals are maintained by DNR. Where possible, the data were downloaded from their web-based data files. Year 2005 data were preliminary and provided by personal communications from DNR staff. The locations are shown in Figure 2 and listed in Table 3.

3. Approach

The general approach in developing an improved understanding of the hydrologic trends and correlations of flow in the Republican River and groundwater levels is subdividing the Republican River basin in Nebraska into groundwater flow zones on the basis of stream segments along the Republican River. The selected segments are separated at key USGS streamflow gages and lakes and include:

1. Nebraska-Colorado and Nebraska-Kansas Statelines to Swanson Lake,
2. Swanson Lake to McCook,
3. McCook to Cambridge,
4. Cambridge to Harlan County Lake, and
5. Harlan County Lake to Hardy.

The groundwater zones were delineated by contouring the groundwater levels measured in the winter or spring of year 2005 and drawing groundwater divides, starting at the boundaries of the stream segments.

For each of these segments, hydrographs were used to summarize and display streamflow, baseflow, runoff for streams, diversions for major canals, and water levels at representative wells. In most cases, these hydrographs were posted on a map to facilitate the development of the understanding of trends in terms of space and time and correlations of the various hydrologic, hydrogeologic and physiographic features.

To further summarize the findings, statistical measures of trends were computed and summarized. Finally, inflow by stream segments were summed to provide a regional characterization of streamflow and baseflow trends along the Republican in Nebraska.

4. 2005 Groundwater Levels and Flow Zones

To characterize recent groundwater conditions, the USGS groundwater data for the study area were screened to select wells with January-June 2005 water-level measurements, sorted to select the most recent value if the well had more than one measurement, and posted on a large scale map. Then, water level contours were drawn by professional judgment in consideration of data values, consistency, potential for outliers, and physiographic features such streams. This 2005 groundwater level map is shown in Figure 3. As previously documented the highest groundwater levels are at the westernmost part of the basin and has a downward gradient toward the Republican River. Groundwater levels in the northern margin of the Republican River basin show a groundwater divide between the Platte and Republican Rivers. Groundwater in the east-central part of the study area flows toward streams in the Little Blue River basin.

The flow zones for the Republican River segments were delineated by drawing a groundwater flow line that terminates at the ends of the segments. These zones are shown in Figure 3 and define, on a regional basis, the area that contributes baseflow to a stream segment. These groundwater flow zones are significant in that they isolate cause and effect areas in the correlation of groundwater and surface water conditions.

5. Regional Changes in Groundwater Levels

To characterize the regional changes in groundwater levels in the study area, especially with regard to recent times, groundwater level hydrographs and available data were reviewed with regard to suitable periods to characterize the changes. From this review, wells with relatively early and current measurements and with an extensive coverage became rather limited prior to 1980. To assess recent changes, a deflection in groundwater level hydrographs was commonly noted in 1999. As a result, the periods from 1980 to 1999 and 1999 to 2005 were selected for study.

The selected method was to use measurements in a common well, instead of mapping the water levels for each of the years and subtracting the elevations of the map surfaces. The selected approach is based directly on data measurements and not on the differences of interpreted water levels.

The groundwater level change maps for 1980-1999 and 1999-2005 are shown in Figures 4 and 5, respectively. The changes are shown in four (4) foot ranges or bands. For correlation purposes, location of irrigation wells and major surface water diversions are shown in Figure 6.

For the 19-year period from 1980-1999, water level declines of more than 12 ft were mapped in northwest Chase and south-central Perkins Counties. Water level rises of more than 12 feet were mapped in parts of central Gospher, Phelps, and Kearney Counties. The importation of surface water from the Platte River into this area for irrigation was, at least, the primary cause of significant rises in groundwater levels.

In general, the western half of the study area commonly showed water level declines and the eastern half commonly showed water level rises. Data are sparse in much of the central area.

For the recent 6-year period which includes a regional drought, the greatest declines in water levels were between 12 and 16 ft and are located in central Chase County. Throughout the study area, water levels, with few exceptions, showed declines. Of great interest, parts of Phelps and Kearney Counties showed water level declines between 8 and 12 ft. In much of these two counties, water level declines were greater than 4 ft. Also of great interest are the two areas just north of the Republican River (southern Gosper and northwest Harlan Counties and east-central Franklin and west-central Webster Counties) where water levels declines were between 4 and 8 ft. In the immediate vicinity of the Republican River and many of its major tributaries, water

level declines were less than 4 ft. No attempt was made to correlate the water levels declines and groundwater pumpage, nor groundwater rises to increased recharge from surface water irrigation.

6. Trends in Groundwater Levels

The approach to characterize the trends in groundwater levels is to display about 10 representative hydrographs on maps for each of the five groundwater flow zones. Because of the interest in the Republican River and, to a lesser degree, in the Frenchman Creek, the selection emphasized wells in these valley areas. These displays are shown in Figures 7 through 11 for the five zones. To facilitate comparisons, the full range scale on the hydrographs is either 20, 50 and 100 ft, and an interval scale is either 5, 10 and 20 ft, respectively. The time scale begins in 1950 and ends in 2010. In a study of the displays, it is important to note that groundwater hydraulics dictates that changes in water levels in well near a stream will have a much more immediate effect on baseflow than remote wells.

Water level hydrographs for wells in the groundwater flow zones for the upper two reaches of the Republican River show long-term, substantial declines in the uplands area of Dundy, Chase and Perkins Counties. The reverse seems to be the case in the uplands area of Gospher, Phelps, and Kearney Counties for the two groundwater flow zones in the lower part of the basin. An exception is the last few years when water levels were declining. In the valley areas, groundwater levels show long-term stability, but some noticeable declines are evident in recent years. In the intermediate area, the signals are mixed with some wells in or near Gospher, Phelps, and Kearney Counties showing slight rises and some wells are showing stable or declining water levels. Most all the wells show some water level decline since the mid-1990s.

7. Trends in Streamflow, Reach Gains, and Diversions

For this study, streamflow is presented as three components. They are total streamflow, baseflow as determined by the separation of streamflow, and runoff being the difference between total streamflow and runoff.

7.1 Total Streamflow

The total streamflow is of great interest because it is the measure of available water for the Compact and for diversions for surface water irrigation.

The compilation of the annual total streamflow is designed to provide a water budget for the inflow into each stream segment. The inflow includes measured or estimated streamflow from the major tributaries, reach gains and losses, and ungaged segments of Swanson and Harlan County Lakes. Hydrographs of annual (water year) values are illustrated on a map showing the groundwater flow zones. The intent is to illustrate the changes in space and time with a goal of eventually correlating trends in groundwater levels and streamflow. For the five zones, maps and hydrographs are presented in Figures 12 through 16.

For the tributaries gages north of the Republican and west of Cambridge, a fairly common pattern is relatively high flows and major fluctuations prior to the mid-1960s and noticeably low or less flows and minor fluctuations since the mid-1960s. Many of these tributaries show that the rate of decline has increased in recent times, and, in some cases, streams are nearly dry. For the tributaries north of the Republican and east of Cambridge, there has been little change in long-term flows except for Turkey Creek at Edison where there is a substantial rises. For the major tributaries south of the Republican, streamflow has deceased to no-flow much of the time.

Reach gains and losses in the Republican River west of McCook and Frenchman Creek typically show slight declining trends. In the middle segment of the Republican River, the reach gains and losses have been stable, except since 1999 when the trend became downward. Downstream of Harlan County Lake, there have been slight rises until the late 1990s when declines began to occur.

To illustrate the long-term changes in streamflow along the main stem of the Republican River and Frenchman Creek, streamflow hydrographs have been prepared and are shown in Figure 17. Consistent along these two streams are substantial declines in streamflows since the mid-1960s. Of great significance, records at several of the stations are showing little or no flow in recent years.

7.2 Baseflow

Baseflow is of interest because its declines are generally related to groundwater irrigation and rises to recharge from imported surface water for irrigation. By zone, maps and baseflow hydrographs are presented in Figures 18 through 22.

For the tributaries gages north of the Republican and west of Cambridge, a common pattern is relatively steep declines since the mid-1960s. For the tributaries north of the Republican and east of Cambridge, there is little change in long-term baseflows except for Turkey Creek at Edison were there are substantial rises. In each of the tributaries, the trends have been noticeably downward since the late 1990s. For the major tributaries south of the Republican, baseflow decreased to the point where it exists only during extended wet periods, except for Driftwood Creek where baseflows trended upward until about 1970, were stable and relatively high between 1970 and 1990, and have declined since. The pattern is strongly related to operations of the Driftwood-Meeker Canal.

The trends in baseflow gains and losses in the Republican River segments generally shows slight declines west of Cambridge and slight rises east of Cambridge. In all cases, noticeable declines are evident since the late 1990s. Reaches in Frenchman Creek show baseflows to be relatively constant between Ender Reservoir and Palisade and declining from Palisade to Culbertson.

7.3 Runoff

In the Republican River basin, a decline in runoff is often attributed to farm ponds, terraces, and tillage practices. By zone, maps and runoff hydrographs are presented in Figures 23 through 27.

The most dominate pattern of annual runoff for all the tributaries and reaches is relatively high flows and fluctuations prior to the mid-1960s and gradual declines since then. One group of exceptions is in baseflow dominated streams (North Fork Republican at Colo-Neb Stateline, Buffalo, and Rock Creeks where the runoff is relatively low and remains stable. Another group of exceptions are in the lower basin where runoff shows considerable fluctuations and either is stable or slightly increases over time. As with total streamflow and baseflow, noticeable declines in runoff are evident throughout the basin since the late 1990s.

7.4 Diversions

A review hydrographs of the diversions to canals upstream of Harlan County Lake shows long-term general declines in most of the canals since 1970 and major declines in all the canals since the late-1990s (Figure 28). Diversions from Harlan County Lake have been stable or

increasing slightly since the 1970s, except since year 2000 when diversions decreased sharply. In 2005, diversions were not made in many of the canals.

7.5 Statistical Summary

To summarize the total streamflow and baseflow information in a statistical format, streamflow averages have been calculated for the early period (1950-1967) and recent period (1999-2005) and trends (average change per year) between the two periods for each of the selected gages and segments. Table 4 presents this summary. This table indicates widespread declines in streamflow and baseflow, with the only strong rise occurring at the Turkey Creek at Edison gage, For the Republican River segments downstream of McCook, there are indications of slight rises in baseflow.

7.6 Summation of Inflows to the Republican River

Using results from the analyses of streamflow and baseflow to tributaries and segments, an accounting of inflow to the Republican has been prepared. The individual components of the inflow include, by segments:

- CO-KS-NE Stateline to Stratton
  - Arikaree River,
  - North Fork Republican River at CO-NE Stateline,
  - South Fork Republican River at Benkelman,
  - Buffalo Creek,
  - Rock Creek, and
  - Intervening Gain-Losses to the main stem.
- Swanson Reservoir (between Stratton and Trenton gages)
- Trenton to McCook
  - Driftwood Creek,
  - Frenchman-Imperial,
  - Enders Reservoir,
  - Intervening Gail-Losses to Frenchman from Enders to Palisade,
  - Stinking Water Creek,
  - Intervening Gail-Losses to Frenchman from Palisade to Culbertson, and
  - Intervening Gain-Losses to the Republican.

- McCook to Cambridge
  - Red Willow Creek,
  - Medicine Creek, and
  - Intervening Gain-Losses to the Republican.
- Cambridge to Orleans
  - Intervening Gain-Losses to the Republican.
- Harlan County Lake (between Orleans and below Harlan gages)
- Below Harlan County Lake to Hardy
  - Intervening Gain-Losses to the Republican between Harlan and Guide Rock, and
  - Intervening Gain-Losses to the Republican between Guide Rock and Hardy.

In this summation process, estimates of streamflow and baseflow had to be made for the segments with Swanson, Enders, and Harlan County Lakes and for baseflow at South Fork of the Republican River at Benkelman. These estimates are based on the following assumptions:

- ***South Fork of the Republican River at Benkelman:*** A review of the total streamflow at this station and Arikaree shows a similar pattern. On this basis, it is assumed that the percent of annual baseflow in the South Fork is the same as in the Arikaree River. The fraction of the baseflow in the Arikaree was calculated and multiplied by the streamflow in the South Fork to provide an estimate of baseflow in the South Fork.
- ***Swanson Lake:*** Average of annual flows at Buffalo and Rock Creeks, and Gain-Loss in segment from Statelines to Stratton.
- ***Enders Reservoir:*** On the basis of length of stream segments and common setting, assumed to be 20 percent of Gain-Loss in Frenchman Creek segment between Enders to Palisade.
- ***Harlan County Lake:*** On the basis of length of stream segments and common setting, assumed to be 20 percent of Gain-Loss in Republican River segment from below Harlan County Lake to Guide Rock.

A graphical summary of these summations are presented for three regional segments with total streamflow and baseflow in Figure 29.

For the total streamflow, a long-term and consistent decline from about 400 cfs to about 75 cfs is noted for the regional segment upstream of McCook. For the regional segment between McCook and Harlan Dam, streamflows were very stable between about 1970 and 2000, higher before 1970 and lower after 2000. Downstream of Harlan Dam, streamflow was slightly increasing until 2002, then became about half of the long-term average. Overall, the total inflow to the Republican River in Nebraska showed a general, long-term decline from about 850 cfs in

the 1960s to about 250 cfs since 2002. A relatively wet period in the mid- and late-1990s appeared to cause streamflow to be temporarily higher than would be indicated by the long-term trend.

Baseflow trends are similar to total streamflow trends. In this case, the summation of baseflow components into the Republican River appears to decline from about 400 cfs from 1960-1970 to about 150 cfs from 2003-2005.

8. Correlating Changes of Streamflows and Groundwater levels

With a general understanding of the patterns and trends in streamflows and groundwater levels, this section focuses on correlating the hydrologic conditions in streams and aquifer. The selected approach is to qualitatively relate the changes in groundwater levels in wells along a flow line to changes in baseflow at hydrologically related tributaries and stream segments. The approach continues the use of displays of maps and hydrographs to illustrate the data and correlations.

8.1 Nebraska-Colorado-Kansas Statelines to Swanson Lake Groundwater Flow Zone

In comparison to the other groundwater flow zones, this one is relative small and is in the proximity of the Republican River. Considering the setting and available data, the selected groundwater flow line extends from the Republican River about 6 miles west of the Dundy-Hitchcock County line to the west northwest. The groundwater conditions are characterized by data from three wells; and baseflow in Buffalo and Rock Creeks and in the stream segment between the gages at statelines and Stratton. These conditions are shown in Figure 30. This illustration shows a relatively close match between the upland groundwater levels and baseflow in the two tributaries. Likewise, the groundwater level pattern in the well near the Republican closely matches the baseflow in the segment.

8.2 Swanson Lake to McCook Groundwater Flow Zone

This flow zone is relatively complex because of its size and the Frenchman Creek watershed. To characterize the correlation, groundwater levels and baseflow hydrographs are compiled along two groundwater flow lines, one along Frenchman Creek and the other from near the mouth of Red Willow Creek to southern Perkins County. The Frenchman flow line is about 70 miles long, and the Red Willow flow line is about 100 miles long. Changes in groundwater

levels at the upper end of the flow line will be reflected in tributary baseflow in a relatively short-term and in the main stem baseflow in a relatively long-term.

For the Frenchman flow line, Figure 31 shows groundwater level hydrographs with a declining pattern for the upper two wells (6N41W2ABBB1 and 6N39W32D1) that are located in the uplands area, and a relatively stable pattern for the other four wells that are located relatively close to the Frenchman and Republican. The illustration shows declining baseflow trends at Frenchman-Imperial correlates with the declining trends of the two upland wells. Baseflow is relatively stable for the Frenchman reach between Enders and Palisade as are groundwater levels for the middle two wells (5N36W5CAB1 and 5N34W30BAA1). The lack of a good correlation of the baseflow in the lower Frenchman and along the Republican with the nearby wells suggests other factors are also affecting the baseflow. One of the factors that may not be captured by the indicator wells is indirect return flows from diversions to Culbertson and Riverside Canals.

The eastern flow line terminates near the mouth of Red Willow Creek (Figure 32). It shows groundwater level hydrographs with a declining pattern for the upper three wells that are located in the uplands area, and corresponding declines in baseflow at Stinking Water Creek. The lower two groundwater level hydrographs (8N35W33ACD1 and 5N23W27BCB1) in middle part of the flow line generally matches the baseflow in the Frenchman segment between Palisade and Culbertson. It appears that the valley well (3N28W19ADB1) does not effectively indicate the regional baseflow between Swanson Lake and McCook.

8.3 McCook to Cambridge Groundwater Flow Zone

This flow zone trends to the northwest from the Republican River and has its headwaters in eastern Perkins, southwest Lincoln, northeast Hayes, and western Frontier Counties. This zone generally represents the intermediate area between the areas with regional declines in groundwater levels in the upper Frenchman Creek basin and the regional rise in groundwater levels in the uplands of Gospher, Phelps and Kearney Counties.

The selected flow line for this zone extends from near the mouth of Medicine Creek to eastern Perkins County, a distance of about 80 miles (Figure 33). Groundwater levels at the northwest well (10N35W1C1) have a pattern that is consistent with baseflow in the upper Frenchman and Stinking Water Creeks which are located in the adjacent western flow zone. This well appears to be too remote to noticeably affect the baseflow at the Red Willow and Medicine

Creek gages. The next well to the Republican (10N32W17CC1) shows a complicated pattern of rises in the mid-1950s, rises till 1970, declines till 1980, relatively stable water levels till 2000 and substantial declines since 2000. Water level changes for the next four wells toward the Republican show minor and mixed trends and fluctuations. The well near the Republican (4N26W23AA1) shows a declining trend since the late 1980s. Baseflows in Red Willow and Medicine Creeks are generally stable till the late 1990s and have declined since. The clearest correlation is between the groundwater levels in well 10N32W17CC1 and the baseflows in Red Willow and Medicine Creeks. Another relatively close correlation is between the groundwater levels in the valley well (4N26W23AA1) and the baseflow in the reach between McCook and Cambridge. Overall, the trends and patterns of groundwater levels and baseflows are consistent with the exception of the uppermost well (10N35W1C1) on the flow line which is very remote from the nearest stream gage in this flow zone. Another influence is local recharge from indirect return flow of diversions to Red Willow and Bartley Canals which would tend to keep the baseflow in the stream segment higher than would occur otherwise.

8.4 Cambridge to Orleans Groundwater Flow Zone

The headwaters of this flow zone captures the southeastern part of Lincoln, eastern Frontier, much of Gospher, and the western part of Phelps Counties. Some of the major surface drainages include Muddy and Turkey Creeks.

Two flow lines are used for this flow zone. One generally follows Muddy Creek; and, the other is in the vicinity of Turkey Creek. These flow lines are much shorter than the others, thus the baseflow responses in the tributaries are expected to be evident more quickly to changes in groundwater levels.

For the western flow line along Muddy Creek, the line extends from near the mouth of Muddy Creek to southeast Lincoln County, a distances of about 50 miles (Figure 34). Groundwater levels at the four northwest wells have rather stable but with slight rises from the early 1990s to early 2000s, then declines to 2005. Of interest is the second well from the Republican River (5N24W27ABCD1) which shows a consistent rise until about 2001, then water levels begin to decline. At the well near the Republican River (4N23W30CC1), water levels have tended to be relatively high in the 1950s and mid-1990s to 2002 and low from 1970 to 1992. The baseflow at the Muddy Creek gage and in the Republican River segment between Cambridge and

Orleans have similar patterns where baseflow gradually rises from relatively low values in the mid-1950s to relatively high values in the mid-1990s, then decline to 2005. These baseflow patterns reflect the groundwater trends in the upper part of the flow line in the earlier times and seem to decline in more recent times that is independent of these indicator wells.

The eastern flow line is of great interest because it is along Turkey Creek (at Edison) which has had a long-term increase in baseflow. The flow line is about 20 miles long and extends into central Gosper County (Figure 35). Groundwater levels at the two northwest wells (7N22W26CBAA1 and 6N21W7BBCC1) have consistent rise until about 2002, then begin to decline. At an intermediate well on the flow line (6N22W25CBCB1), the trends are similar but at lesser rates. However, at well 5N22W29AABC1, there has been a long-term and consistent decline since the mid-1970s. At the well near the Republican River (4N21W24ABAD1), water levels have tended to always return to near long-term averages. The baseflow pattern at the Turkey Creek at Edison gage shows gradual rises between the late-1970s to early 1990s, substantial rises till about 2000, the slight declines since. The pattern seems to reflect the pattern of groundwater levels in the upper part of the flow line to a great degree. The baseflow in the Republican River between Cambridge and Orleans has a pattern where baseflow gradually rises from relatively low values in the mid-1950s to relatively high values in the mid-1990s, then decline to 2005. A very strong influence appears to be diversions to Cambridge Canal. In summary, these patterns seem to reflect the groundwater trends in the upper part of the flow line in the earlier times and groundwater conditions in the lower part during more recent times.

8.5 Harlan County Lake to Hardy Groundwater Flow Zone

The headwaters of this flow zone are in southeastern Phelps and southwestern Kearney Counties. Some of the major surface drainages include Turkey (north of Harlan County Lake), Center and Thompson Creeks. The eastern half of the zone is a relatively narrow east-west band that is limited by the Little Blue River drainage.

Two flow lines are used for this flow zone. One generally extends north of Harlan County Lake; and, the other extends from west of Guide Rock to western Kearney County.

For the western flow line north of Harlan County Lake, the line extends to central Phelps County, a distances of about 25 miles (Figure 36). Groundwater levels at the most northern well (6N18W27CC1) show a long-term rise which is common in eastern Phelps and central Kearney

Counties. The central well (5N18W35CB1) and two southern wells show declines until the early 1990s, rises till the early 2000s then noticeable declines to 2005. The Center Creek gage indicates rather stable baseflows from the mid-1950s to mid-1990s, then a decline. The missing record from 1995 to 2002 does not allow one to closely correlate groundwater levels and baseflows in more recent times. The baseflow in the Republican River between Harlan County Lake and Guide Rock generally follows the rises in groundwater levels in the upper basin from the mid-1950s to early 1980s, but shows influence of local groundwater levels since the late-1980s. Of interest, it also generally follows the pattern of diversions to the Franklin, Naponee, and Franklin Pump Canals.

For the eastern flow line north of Harlan County Lake, the line extends from near Guide Rock to western Kearney County, a distance of about 40 miles (Figure 37). Groundwater levels at the Kearney County wells (6N16W29DA1 and 5N14W26CDBB1) show long-term rises in water levels and recent declines. The central well (4N13W13BCD1) shows long-term declines to the mid-1990s, a sharp rise, then substantial declines to 2005. Water levels in the two wells near the Republican River show relatively stable water levels, but declines in recent years. Baseflow in Elm and Thompson Creeks shows a pattern that is generally consistent with the central well (4N13W13BCD1), and not the wells in Kearney County. The baseflow pattern in the Republican River between Guide Rock and Hardy generally follows the local water levels and the annual diversions to Courtland and Superior Canals.

Table 1.
Well Records for Water Level Data Used in Trend Analysis (page 1 of 9)

USGS ID	Nebraska ID	Latitude (dec)	Longitude (dec)	Date Constructed	Land Surface Elev (ft)	Well Depth (ft)
400032101022901	1N 33W33CB 1	40.00889	-101.04183		2995	
400038099244601	1N 19W36ACCA1	40.01057	-99.41316	1970	1988	69
400050098083001	1N 7W32BB 1	40.01390	-98.14199	1947	1577	11.9
400130101093702	1N 34W28DC 2	40.02500	-101.16072		3000	
400130101374401	1N 38W29AD 1	40.02499	-101.62934	1946	3040	22
400134100283101	1N 28W27BCA 1	40.02612	-100.47570	1968	2488	42
400140098004601	1N 6W29AACD1	40.02779	-98.01310	1976	1629	87
400155101521302	1N 40W29BB 2	40.03194	-101.87073	1974	3205	49
400227100480701	1N 31W22CA 1	40.04084	-100.80238		2720	
400239098152001	1N 8W20BBBC1	40.04460	-98.25533	1972	1611	39
400240098111301	1N 8W23AB 1	40.04446	-98.18727	1950	1598	18
400339098153801	1N 8W 7DD 1	40.06085	-98.26088	1946	1613	12
400400100531501	1N 32W12BC 1	40.06667	-100.88793		2780	53
400423098314001	1N 11W11AB 1	40.07307	-98.52812	1946	1686	17
400449100125101	1N 26W 1CB 1	40.08028	-100.21153		2352	54
400519101281401	1N 37W 2BBA 1	40.08861	-101.47100		2950	
400539098234501	2N 10W36DB 1	40.09418	-98.39617	1932	1700	35
400551101260301	2N 36W31BC 1	40.09750	-101.43461	1946	2916	28
400604101494301	2N 40W34BACC1	40.10110	-101.82907	1969	3380	108
400610100174201	2N 26W31AAB 1	40.10167	-100.29098	1979	2550	220
400617101074801	2N 34W26C 1	40.10472	-101.13044		2950	
400648100491201	2N 31W28BA 1	40.11334	-100.82043		2715	
400657100540601	2N 32W27AA 1	40.11667	-100.90932		2850	
400702100401801	2N 30W27AD 1	40.11139	-100.68654		2735	
400704099352701	2N 20W28BBBA1	40.11779	-99.59122	1969	2022	52
400722098251001	2N 10W23CACC1	40.12279	-98.41978	1973	1835	195
400736101141901	2N 35W23BD 1	40.12666	-101.23905	1961	2805	46
400737101041601	2N 33W20BD 1	40.12694	-101.07155		2880	
400748101124501	2N 35W24AA 1	40.13000	-101.21294	1946	2778	12
400751098394601	2N 12W22BA 1	40.13085	-98.66312	1967	1945	153
400757098442001	2N 13W24BABA1	40.13251	-98.73924	1979	1960	130
400808098270901	2N 10W16DCBC1	40.13557	-98.45284	1973	1760	108
400817098394601	2N 12W15CA 1	40.13807	-98.66312	1968	1965	161
400824099154501	2N 17W17DBBB1	40.14001	-99.26287	1968	2111	175
400831100311401	2N 28W18BD 1	40.14195	-100.52098		2630	
400835100383501	2N 29W18CB 1	40.14306	-100.64349		2580	

Table 1.
Well Records for Water Level Data Used in Trend Analysis (page 2 of 9)

USGS ID	Nebraska ID	Latitude (dec)	Longitude (dec)	Date Constructed	Land Surface Elev (ft)	Well Depth (ft)
400842101122301	2N 34W18BB 1	40.14500	-101.20683	1967	2790	54
400850100270001	2N 28W11DCCC1	40.14834	-100.44987	1971	2510	148
400852101352701	2N 38W10DD 1	40.14777	-101.59128	1972	3265	180
400855101023601	2N 33W 9DD 1	40.14861	-101.04377	1956	2734	50
400931098262001	2N 10W10B 1	40.15862	-98.43922	1973	1770	90
400933098472001	2N 13W 9ABD 1	40.15918	-98.78924	1977	1880	178
400935098545201	2N 14W 9BBCB1	40.15974	-98.91480	1964	2073	
400949098402001	2N 12W 4DD 1	40.16363	-98.67257		1925	
400951098545201	2N 14W 4CCBC1	40.16418	-98.91480	1964	2074	210
400954098453201	2N 13W 2CDBB1	40.16501	-98.75924	1978	1930	124
400959098443101	2N 13W 1CBD 1	40.16640	-98.74229	1956	2005	212
401015098465101	2N 13W 3BC 1	40.17085	-98.78119	1956	1870	51
401024098473901	2N 13W 4BADC1	40.17335	-98.79452	1970	1890	97
401025098280001	2N 10W 5AACC1	40.17362	-98.46700	1976	1892	204
401029099114201	2N 17W 1BB 1	40.17473	-99.19537	1954	2030	
401033099204001	2N 18W 3BBBB1	40.17584	-99.34482	1968	2135	235
401034098343401	2N 11W 5AAAA1	40.17612	-98.57645	1977	1920	247
401034099122601	2N 17W 2BAAA1	40.17612	-99.20759	1970	2035	174
401046100163701	3N 26W32DDBB1	40.17945	-100.27736	1971	2454	150
401059098390101	3N 12W35CBBB1	40.18307	-98.65062	1974	2008	273
401105101292401	3N 37W34BCDB1	40.18555	-101.48989	1973	3189	210
401110100544901	3N 32W34ADBB1	40.18611	-100.91405		2624	38
401130100533601	3N 32W26DD 1	40.19167	-100.89377	1946	2631	74
401146100201201	3N 27W26DB 1	40.19612	-100.33709		2553	
401212101204101	3N 36W26ABAD1	40.20333	-101.34516	1971	3010	150
401213098544601	3N 14W28BB 1	40.20362	-98.91314	1952	2091	190
401221098423401	3N 12W19DDDC1	40.20585	-98.70979	1974	2030	268
401228101154901	3N 35W21DA 1	40.20694	-101.26822		3087	
401229098472001	3N 13W21DCA 1	40.20807	-98.78924	1956	2015	183
401232101291701	3N 37W22CACC1	40.20888	-101.48850	1971	3192	240
401233099062701	3N 16W22DACC1	40.20918	-99.10787	1964	2192	295
401234099240301	3N 18W19CBDD1	40.20946	-99.40121	1963	2192	265
401236101020301	3N 33W22CA 1	40.21000	-101.03461	1969	2872	210
401257100310701	3N 28W19ADB 1	40.21584	-100.51904		2422	
401258101083401	3N 34W22BB 1	40.21611	-101.14322		2980	
401307101222101	3N 36W22BBAA1	40.22027	-101.37711	1966	3196	320

Table 1.
Well Records for Water Level Data Used in Trend Analysis (page 3 of 9)

USGS ID	Nebraska ID	Latitude (dec)	Longitude (dec)	Date Constructed	Land Surface Elev (ft)	Well Depth (ft)
401329100241701	3N 27W17CB 1	40.22473	-100.39820	1946	2373	16.4
401351099272601	3N 19W15BBDD1	40.23084	-99.45760	1988	2225	273
401357099314401	3N 20W13BA 1	40.23251	-99.52927	1955	2155	
401400099304101	3N 19W18BAB 1	40.23334	-99.51177	1971	2174	180
401401101510701	3N 40W16BBB 1	40.23360	-101.85240	1977	3458	205
401417100273401	3N 28W11CBCC1	40.24001	-100.45904	1974	2440	152
401418099245501	3N 19W12CADD1	40.23834	-99.41566	1955	2215	278
401451099574601	3N 23W 7BBAD1	40.24751	-99.96318	1974	2392	294
401454099172601	3N 17W 7BBBB1	40.24834	-99.29093	1974	2263	345
401456098581301	3N 15W 1CCCC1	40.24890	-98.97064	1980	2122	260
401457098450701	3N 13W 2DCDC1	40.24918	-98.75229	1971	2096	239
401457099254501	3N 19W 2DCDD1	40.24918	-99.42955	1965	2158	212
401457099544201	3N 23W 4DDDD1	40.24917	-99.91263	1970	2283	203
401459098325801	3N 11W 3CD 1	40.24974	-98.54979	1965	2000	200
401503100425601	3N 30W 4CDB 1	40.25084	-100.71599		2688	179
401520099162701	3N 17W 6DAAB1	40.25557	-99.27454	1966	2218	254
401520099561801	3N 23W 5DBBB1	40.25556	-99.93874	1975	2340	250
401527100000601	3N 24W 2BCD 1	40.25751	-100.00207	1968	2348	221
401533099282901	3N 19W 4BDBB1	40.25918	-99.47510	1968	2255	314
401548101080501	4N 34W34DDD 1	40.26333	-101.13516	1977	2975	275
401553098491601	4N 13W31DDDA1	40.26474	-98.82146	1976	2115	240
401612100203501	4N 27W35CABB1	40.27001	-100.34348	1976	2480	191
401612101242701	4N 36W32BDCD1	40.26999	-101.40794	1966	3251	392
401624100501601	4N 31W32A 1	40.27333	-100.83821		2665	
401637100294401	4N 28W33BBBA1	40.27695	-100.49598	1971	2556	233
401638099310801	4N 20W36AAAB1	40.27723	-99.51927	1965	2248	286
401647099575301	4N 23W30CC 1	40.27973	-99.96513	1939	2240	93
401651099250701	4N 19W25CDBB1	40.28084	-99.41899	1976	2255	340
401701099270101	4N 19W27DBBD1	40.28362	-99.45066	1966	2295	342
401703101394801	4N 38W30BCC 1	40.28583	-101.66323	1972	3317	180
401705099363901	4N 20W29CBBB1	40.28473	-99.61122	1972	2222	212
401706100495501	4N 31W28BCC 1	40.28500	-100.83238	1972	2724	185
401707099021201	4N 15W29ACCC1	40.28529	-99.03703	1964	2188	282
401717099190301	4N 18W26ACBA1	40.28807	-99.31787	1962	2253	247
401721101011201	4N 33W26BABA1	40.28916	-101.02044	1968	2728	
401734099353101	4N 20W21CCCC1	40.29279	-99.59233	1975	2235	227

Table 1.
Well Records for Water Level Data Used in Trend Analysis (page 4 of 9)

USGS ID	Nebraska ID	Latitude (dec)	Longitude (dec)	Date Constructed	Land Surface Elev (ft)	Well Depth (ft)
401801098104501	4N 8W24BCC 1	40.30029	-98.17949	1968	1813	200
401801101002301	4N 33W23AD 1	40.30028	-101.00683	1946	2675	19
401817098232401	4N 10W24AACA1	40.30474	-98.39033	1968	1960	133
401817100535501	4N 32W23ABB 1	40.30472	-100.89905		2824	
401819100130801	4N 26W23AA 1	40.30528	-100.21931	1968	2426	166
401820099380601	4N 21W24ABAD1	40.30556	-99.63539	1976	2200	190
401826101060101	4N 34W13DD 1	40.30722	-101.10072		2884	
401832099445401	4N 22W13DCBD1	40.30890	-99.74873	1972	2170	105
401834100323501	4N 29W13CDAA1	40.30945	-100.54348	1970	2594	261
401836098471401	4N 13W16DDBB1	40.31001	-98.78757	1978	2108	241
401848101152501	4N 35W10CB 1	40.24527	-101.26572		3145	
401850098442601	4N 13W13BCD 1	40.31390	-98.74091	1964	2080	212
401905098432101	4N 11W13CDBB1	40.30946	-98.51478	1957	2010	155
401907099301601	4N 19W18ABD 1	40.31862	-99.50483	1957	2290	227
401910099470601	4N 22W15AB 1	40.31945	-99.78540	1968	2270	187
401916098252101	4N 10W11CCD 1	40.32112	-98.42284	1957	1983	130
401921099130401	4N 17W10DDDB1	40.32251	-99.21815		2255	
401928098292502	4N 10W 7DCBB1	40.32446	-98.49062	1971	1970	139
401928099274301	4N 19W 9DDAA1	40.32445	-99.46233	1974	2342	283
401929098583201	4N 15W11DO 1	40.32474	-98.97592	1975	2130	248
401956098453401	4N 13W11BO 1	40.33224	-98.75980	1977	2045	188
402009100381201	4N 29W 7B 1	40.33584	-100.63710		2600	
402010098084801	4N 7W 6DDCC1	40.33668	-98.14782	1971	1798	145
402027099423701	4N 21W 5DBDB1	40.34084	-99.71067	1968	2265	239
402028098331901	4N 11W 3CBB 1	40.34113	-98.55562	1955	1965	170
402037099483601	4N 22W 4BDCC1	40.34362	-99.81040	1974	2267	195
402040100183901	4N 27W 1ADDA1	40.34445	-100.31125	1972	2549	230
402051100592301	4N 33W19ACB 2	40.34750	-100.98433	1977	2917	320
402058099471901	4N 22W 3BAA 1	40.34945	-99.78901	1967	2302	241
402100101433801	5N 39W34DCDB1	40.34999	-101.72767	1969	3338	305
402101099595001	4N 24W 2BAAB1	40.35028	-99.99763		2378	
402107101063001	5N 33W31DCB 1	40.35194	-101.10877		2750	23
402110099140001	5N 17W34CC 1	40.35200	-99.23292		2281.57	
402124099201601	5N 18W35CB 1	40.35635	-99.34038	1954	2316.61	223
402148098454500	5N 13W34AAAD1	40.36335	-98.76285	1957	2110	222
402202099082201	5N 16W28CC 1	40.36611	-99.14129	1954	2202.85	240

Table 1.
Well Records for Water Level Data Used in Trend Analysis (page 5 of 9)

USGS ID	Nebraska ID	Latitude (dec)	Longitude (dec)	Date Constructed	Land Surface Elev (ft)	Well Depth (ft)
402204098521200	5N 14W26CDBB1	40.36779	-98.87036	1972	2146	265
402209098311801	5N 11W26DBDC1	40.36918	-98.52201	1970	1933	180
402224100570501	5N 32W27BCB 1	40.37528	-100.94710	1971	2910	344
402225101263301	5N 36W30DBBA1	40.37361	-101.44294	1968	3314	475
402236100013201	5N 24W27ABCD1	40.37667	-100.02596	1973	2393	172
402236101343101	5N 38W25ADBA1	40.37499	-101.57572	1965	3397	474
402241099495600	5N 22W29AABC1	40.37806	-99.83262	1972	2325	242
402244101132101	5N 34W30BAA 1	40.37889	-101.22294		2819	17
402250100285801	5N 28W22CD 1	40.38056	-100.48320	1955	2570	252
402254099062201	5N 16W22DD 1	40.37973	-99.10889		2200.23	
402352098524600	5N 14W15DACC1	40.39779	-98.87980	1957	2175	269
402411098370101	5N 12W13AC 1	40.40307	-98.61729	1955	1952	188
402415098311601	5N 11W14ACA 1	40.40418	-98.52145	1954	1870	120
402416099560500	5N 23W16ACBB1	40.40445	-99.93513	1974	2380	221
402419101495401	5N 40W14BO 1	40.40333	-101.83157	1975	3410	325
402442098423301	5N 12W 7DDBB1	40.41168	-98.70952	1977	2046	233
402521099493900	5N 22W 9BBBB1	40.42251	-99.82790	1972	2400	242
402532099235801	5N 18W 6DD 1	40.42702	-99.39881	1957	2325.54	183
402534098441600	5N 13W 1CDBB1	40.42613	-98.73813	1976	2055	247
402534101274801	5N 37W 1DCBD1	40.42611	-101.46378	1969	3012	155
402535101255501	5N 36W 5CAB 1	40.42639	-101.43239		2990	
402555100021000	5N 24W 3BCCB1	40.43195	-100.03652	1975	2360	124
402612098585401	5N 15W 2BA 1	40.43753	-98.98014	1961	2193.07	193
402612099025401	5N 15W 6AA 1	40.43753	-99.04679	1961	2203.13	152
402614100373001	6N 29W32CCC 1	40.43751	-100.64793	1977	2826	323
402619101454501	6N 39W32D 1	40.43861	-101.76295	1970	3362	330
402623100222001	6N 27W34DCC 1	40.43973	-100.37264	1977	2674	269
402625098594501	6N 15W34DC 1	40.44029	-98.99619	1968	2181	210
402627099573400	6N 23W32CCAA1	40.44084	-99.95985	1971	2355	151
402632098310801	6N 11W35DAC 1	40.44224	-98.51923	1976	1940	247
402636098534401	6N 14W33DADD1	40.44323	-98.89488	1992	2181	250
402703099150901	6N 17W33BB 1	40.44981	-99.25547		2259.02	
402704098400501	6N 12W33AAA 1	40.45113	-98.66840	1977	1970	168
402708098510400	6N 14W25CDCC1	40.45317	-98.85167	1955	2138.2	
402716099212401	6N 18W27CC 1	40.45291	-99.35929	1957	2306.12	187
402716099520700	6N 22W30CCBC1	40.45584	-99.86790	1975	2352	166

Table 1.
Well Records for Water Level Data Used in Trend Analysis (page 6 of 9)

USGS ID	Nebraska ID	Latitude (dec)	Longitude (dec)	Date Constructed	Land Surface Elev (ft)	Well Depth (ft)
402718098461500	6N 13W27DCBB1	40.45501	-98.77119	1974	2055	210
402726099461700	6N 22W25CBCB1	40.45723	-99.77179	1976	2424	342
402729099083901	6N 16W29DA 1	40.45601	-99.14213	1957	2230.02	205
402739100304001	6N 28W28CB 1	40.46084	-100.51154		2785	
402751100510801	6N 31W28BAB 1	40.46417	-100.85266	1968	2842	302
402752100171601	6N 26W28BD 1	40.46084	-100.28097	1953	2410	
402817100583401	6N 32W20CC 1	40.47139	-100.97655		2988	
402835099281401	6N 19W22BC 1	40.47236	-99.47407		2367.28	
402838100010601	6N 24W23BCB 1	40.47723	-100.01874	1977	2502	300
402849100090401	6N 25W22BBBB1	40.48028	-100.15152	1970	2550	277
402851101290701	6N 37W23BABA1	40.48055	-101.48794	1968	3326	471
402856100412301	6N 30W23AB 1	40.46973	-100.69210		2730	
402910098352101	6N 11W17CB 1	40.48613	-98.58951	1968	1980	210
402910101250801	6N 36W17DBDA1	40.48472	-101.42461	1972	3288	495
402950101052601	6N 33W 8CDA 1	40.49723	-101.09099	1954	2919	203
403000098370101	6N 12W12DB 1	40.50001	-98.61729	1947	2015	187
403004101210301	6N 36W12CAD 1	40.50111	-101.35127	1969	3001	190
403005100231401	6N 27W 9A 1	40.50140	-100.38764		2600	
403026099451000	6N 21W 7BBCC1	40.50723	-99.75317	1976	2500	242
403044101140601	6N 35W 1DDCD1	40.51056	-101.23349	1961	3078	332
403046101082001	6N 34W 2DDB 1	40.51278	-101.13933	1970	3089	400
403048098443300	6N 13W 1CCBB1	40.51335	-98.74285	1967	2055	185
403124101562401	6N 41W 2ABBB1	40.52333	-101.94046	1966	3478	309
403127098303601	6N 11W 1BABB1	40.52418	-98.51034	1965	1928	160
403127101012701	7N 33W35DDD 1	40.52417	-101.02460	1977	3048	410
403137099100301	7N 16W31DC 1	40.52513	-99.16797		2221.65	140
403137099330201	7N 20W35DD 1	40.52638	-99.54963	1961	2403.36	168
403147098300701	7N 11W36DBD 1	40.52974	-98.50229	1953	1946	
403212100145701	7N 26W34AA 1	40.53667	-100.24958		2540	
403217099312001	7N 19W31BA 1	40.53928	-99.52074		2446.41	
403229098490500	7N 13W29CCBC1	40.54140	-98.81841	1968	2095	193
403233099561400	7N 23W28CDAB1	40.54251	-99.93762	1974	2580	373
403235101395501	7N 38W29CBB 1	40.54305	-101.66573	1964	3290	230
403242100235801	7N 27W28CBB 1	40.54501	-100.39986	1956	2578	
403246099471200	7N 22W26CBAA1	40.54612	-99.78706	1972	2620	327
403254101211301	7N 36W25BDCB1	40.54833	-101.35405	1968	3046	191

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Well Records for Water Level Data Used in Trend Analysis (page 7 of 9)

USGS ID	Nebraska ID	Latitude (dec)	Longitude (dec)	Date Constructed	Land Surface Elev (ft)	Well Depth (ft)
403256100042701	7N 24W29BC 1	40.54890	-100.07457	1966	2519	223
403303098383901	7N 12W26BBD 1	40.55085	-98.64451	1975	2055	200
403304098343201	7N 11W29AAC 1	40.55113	-98.57590	1973	1990	194
403306098525700	7N 14W27AB 1	40.55168	-98.88286	1955	2123	170
403331100341101	7N 29W24CC 1	40.55862	-100.57015		2870	
403412101484501	7N 40W13CCA 1	40.57000	-101.81295	1968	3406	297
403446100522301	7N 31W17BBD 1	40.57945	-100.87349	1970	2939	450
403453100270601	7N 28W13BAB 1	40.58472	-100.45278	1968	2652	280
403501098334901	7N 11W 9CDD 1	40.58363	-98.56396	1974	2040	201
403506099395301	7N 21W11DD 1	40.58337	-99.66133	1961	2479.44	182
403506100560401	7N 32W10DDAC1	40.58362	-100.92988	1956	2845	190
403516101560601	7N 41W11DAA 1	40.58777	-101.93546	1973	3506	192
403527098421401	7N 12W 8BCC 1	40.59085	-98.70424	1976	2037	182
403534100054601	7N 25W12ADA 1	40.59278	-100.09652	1956	2585	
403546100142701	7N 26W11BAB 1	40.59612	-100.24125	1968	2705	295
403608100022501	7N 24W 4DAC 1	40.60223	-100.04068	1973	2635	443
403626099451401	7N 21W 6BC 1	40.60723	-99.75428		2467	132
403637100452801	7N 30W 5BBB 1	40.61029	-100.75821	1957	2960	348
403638101134401	7N 34W 6BBB 1	40.61056	-101.22933	1977	3174	480
403650099421001	8N 21W33DD 1	40.61224	-99.70051	1961	2555.83	252
403713101173701	8N 35W33ACD 1	40.62028	-101.29405	1969	3135	390
403718100255801	8N 27W31BDB 1	40.62167	-100.43320	1955	2692	
403817100550401	8N 32W26AAC 1	40.63806	-100.91821	1970	2937	404
403838101021701	8N 33W23C 1	40.64390	-101.03849	1974	3180	613
403843101295201	8N 37W22DACB1	40.64528	-101.49822	1966	3237	297
403913100295401	8N 28W21AA 1	40.65362	-100.49876	1956	2700	426
403928101220501	8N 36W13DAC 1	40.65750	-101.35016	1971	3257	440
403940100091101	8N 25W22BB 1	40.65501	-100.14874		2710	
404015100191401	8N 26W 7CCD 1	40.67140	-100.31792	1967	2805	570
404020099502801	8N 22W 8CD 1	40.66951	-99.84343		2613.65	
404023101474701	8N 39W 7CBCC1	40.67305	-101.79684	1970	3425	310
404046099504501	8N 22W 8BC 1	40.67630	-99.85018	1935	2629.13	256
404129100340901	8N 29W12BBB 1	40.68501	-100.56987	1977	2815	520
404134100450201	8N 30W 5BDD 1	40.69279	-100.75098	1968	2921	469
404150100040401	8N 24W 5BA 1	40.69723	-100.06818	1989	2694	380
404156099555300	8N 23W 4ABAA1	40.69890	-99.93179	1974	2630	240

Table 1.
Well Records for Water Level Data Used in Trend Analysis (page 8 of 9)

USGS ID	Nebraska ID	Latitude (dec)	Longitude (dec)	Date Constructed	Land Surface Elev (ft)	Well Depth (ft)
404157101060001	9N 33W32DCD 1	40.69917	-101.10043	1977	3169	
404159100494601	8N 31W 3BABA1	40.69973	-100.82987	1978	3080	640
404219100011801	9N 24W35DB 1	40.70538	-100.02355	1981	2759.7	426
404221101575501	9N 41W35ACC 1	40.70583	-101.96574		3532	
404232100051501	9N 25W32BC 1	40.70723	-100.20374	1965	2758	315
404232101234801	9N 36W35BACA1	40.70889	-101.39711	1971	3252	485
404258101501401	9N 40W25C 1	40.71611	-101.83768	1973	3450	350
404320101180401	9N 35W27BAC 1	40.72222	-101.30155	1968	3263	492
404419100580201	9N 32W21A 1	40.73862	-100.96765		3060	
404426101341301	9N 37W20BBAB1	40.74305	-101.56739	1973	3326	325
404438101283201	9N 36W18CCAB1	40.74528	-101.47128	1972	3196.97	395
404444101410001	9N 38W17CCAA1	40.74555	-101.68378	1974	3381	280
404510101020001	9N 33W13B 1	40.75279	-101.03376		3000	
404513101382301	9N 38W15ABCC1	40.75361	-101.64017	1973	3340	370
404519101170301	9N 35W23BBB 1	40.74083	-101.28488	1975	3245	298
404536101494001	9N 40W12D 1	40.76000	-101.82823	1967	3465	273
404603100445101	9N 30W 9B 1	40.76751	-100.74793	1973	2852	300
404620101433401	9N 39W 2DDDD1	40.77222	-101.72656	1974	3413	225
404649100231601	9N 27W 3BC 1	40.78029	-100.38819		2820	
404649101103601	9N 34W 3ACA 1	40.78028	-101.17710	1973	3136	500
404655100551101	9N 32W 1B 1	40.78195	-100.92015		3098	
404706101282201	10N 36W31CCCC1	40.78500	-101.47322	1990	3236	440
404709100532501	9N 31W 6BA 1	40.78584	-100.89070		3020	
404742101010801	10N 33W36ADD 1	40.79584	-101.01960	1978	3089	600
404840100565401	10N 32W27A 1	40.81112	-100.94876		3094	
404854100451401	10N 30W20DDD 1	40.81528	-100.75431	1978	2975	650
404906102000001	10N 41W21DO 1	40.81833	-101.99852	1973	3566	345
404925101070401	10N 33W19AD 1	40.82361	-101.11821		3047	
404932100384101	10N 29W20BDAA1	40.82556	-100.64514	1969	2960	420
404953100595401	10N 32W17CC 1	40.83140	-100.99876		3123	210
405000101510401	10N 40W14DBCC1	40.83333	-101.85157	1965	3478	308
405019101132701	10N 34W17BCA 1	40.83861	-101.22460	1957	3192	344
405026101343701	10N 37W18AAC 1	40.84055	-101.57739	1971	3315	435
405047101282801	10N 36W 7CCAA1	40.84639	-101.47489	1972	3293	463
405139101155000	10N 35W 1C 1	40.86083	-101.26433	1967	3196	370
405142101395501	10N 38W 4CCA 1	40.86166	-101.66573	1974	3367	425

Table 1.
Well Records for Water Level Data Used in Trend Analysis (page 9 of 9)

USGS ID	Nebraska ID	Latitude (dec)	Longitude (dec)	Date Constructed	Land Surface Elev (ft)	Well Depth (ft)
405222101461801	10N 39W 4ABB 1	40.87139	-101.77378	1951	3440	
405304100413401	11N 30W36BBD 1	40.88445	-100.69320	1972	2978	300
405331101384002	11N 38W27CACC1	40.89194	-101.64489	1969	3378	406
405357101490401	11N 39W30B 1	40.89916	-101.81823	1974	3455	385
405445101261401	11N 36W21B 1	40.91250	-101.43767	1975	3390	440
405449101341101	11N 37W20BBD 1	40.91361	-101.57017		3360	
405506101582301	11N 41W14CCDB1	40.91833	-101.97351	1968	3565	402
405532101105700	11N 34W15BD 1	40.92667	-101.18571		3190	
405557100564501	11N 32W10DD 1	40.93250	-100.94598	1955	3095	220
405602101173101	11N 35W10D 1	40.93389	-101.29238	1970	3218	425
405631101151301	11N 35W12AACC1	40.94194	-101.25405	1967	3225	383
405637101035201	11N 33W10AB 1	40.94250	-101.06321	1979	3160	419
405732100531201	11N 31W 5BBB 1	40.95889	-100.88709	1978	3081	720
405738101423202	12N 38W31CCCC2	40.96055	-101.70851	1976	3423	557

Table 2.
List of Streamflow Gage Stations

USGS ID	*Site Name*	*Latitude (dec)*	*Longitude (dec)*
6821500	ARIKAREE RIVER AT HAIGLER, NE	40.02917	101.96944
6823000	NORTH FORK REPUBLICAN RIVER AT COLO-NE STATELINE	40.06944	102.05083
6823500	BUFFALO CREEK NR HAIGLER, NE	40.03944	101.86583
6824000	ROCK CREEK AT PARKS, NE	40.04167	101.72778
6827500	SOUTH FORK REPUBLICAN RIVER NR BENKELMAN, NE	40.00944	101.54222
6828500	REPUBLICAN RIVER AT STRATTON, NE	40.14056	101.22972
6829500	REPUBLICAN RIVER AT TRENTON, NE	40.16667	101.04778
6831500	FRENCHMAN CREEK NR IMPERIAL, NE	40.42917	101.62361
6835000	STINKING WATER CREEK NR PALISADE, NE	40.36944	101.11389
6835500	FRENCHMAN CREEK AT CULBERTSON, NE	40.23472	100.87778
6836500	DRIFTWOOD CREEK NR MCCOOK, NE	40.14583	100.67278
6837000	REPUBLICAN RIVER AT MCCOOK NE	40.18750	100.61806
6837300	RED WILLOW CREEK ABV HUGH BUTLER LAKE, NE	40.40139	100.78333
6841000	MEDICINE CREEK ABV HARRY STRUNK LAKE, NE	40.50278	100.32222
6843500	REPUBLICAN RIVER AT CAMBRIDGE, NE	40.28472	100.14306
6844000	MUDDY CREEK AT ARAPAHOE, NE	40.30556	99.91111
6844210	TURKEY CREEK AT EDISON, NE	40.27083	99.73333
6844500	REPUBLICAN RIVER NR ORLEANS, NE	40.13139	99.50222
6847500	SAPPA CREEK NR STAMFORD, NE	40.13139	99.55417
6848500	PRAIRIE DOG C NR WOODRUFF, KS	39.98583	99.47750
6849500	REPUBLICAN RIVER BLW HARLAN COUNTY LAKE, NE	40.07917	99.16806
6851000	CENTER CREEK AT FRANKLIN, NE	40.10333	98.97917
6851500	THOMPSON CREEK AT RIVERTON, NE	40.08917	98.76056
6852000	ELM CREEK AT AMBOY, NE	40.08889	98.43528
6853020	REPUBLICAN RIVER AT GUIDE ROCK, NE	40.06361	98.33139
6853500	REPUBLICAN RIVER NR HARDY, NE	39.99250	97.93139

Table 3.
List of Major Canals

Canal No	Canal Name	Lat DD	Long DD
54000	Franklin Pump	40.08194	98.92389
87000	Meeker-Driftwood	40.15417	101.06889
127000	Riverside	40.27000	100.94028
61400	Haigler	40.05944	102.05056
35000	Culbertson	40.36187	101.12647
6000	Bartley	40.22510	100.38697
126000	Red Willow	40.28472	100.54333
20000	Cambridge	40.28513	100.12054
53000	Franklin	40.06722	99.20694
105000	Naponee	40.05278	99.20694
137000	Superior	40.06900	98.37692
310000	Courtland	40.06756	98.37721

Table 4.
Average Streamflow and Baseflow for Early and Recent Periods and Trends between Periods (page 1 of 2)

Station & Reach	Average Total Streamflow (cfs)		Average Baseflow (cfs)		Trend between 1950-1967 & 1999-2005 (cfs/yr)	
	1950-1967	1999-2005	1950-1967	1999-2005	Streamflow	Baseflow
Tributaries						
ARIKAREE RIVER AT HAIGLER, NE	23.7	1.7	9.2	0.8	-0.51	-0.19
NORTH FORK REPUBLICAN RIVER AT COLO-NE STATELINE	72.4	37.5	63.0	32.8	-0.80	-0.69
BUFFALO CREEK NR HAIGLER, NE	14.5	7.6	13.6	6.6	-0.16	-0.16
ROCK CREEK AT PARKS, NE	7.8	3.2	7.2	2.6	-0.11	-0.11
SOUTH FORK REPUBLICAN RIVER NR BENKELMAN, NE	52.1	2.6			-1.14	
FRENCHMAN CREEK NR IMPERIAL, NE	73.4	10.6	66.4	9.2	-1.44	-1.31
STINKING WATER CREEK NR PALISADE, NE	44.8	15.5	34.8	12.7	-0.67	-0.51
FRENCHMAN CREEK AT CULBERTSON, NE	113.1	26.4			-1.99	
DRIFTWOOD CREEK NR MCCOOK, NE	11.2	2.8	1.1	1.9	-0.19	0.02
RED WILLOW CREEK ABV HUGH BUTLER LAKE, NE	30.7	12.7	17.5	10.1	-0.41	-0.17
MEDICINE CREEK ABV HARRY STRUNK LAKE, NE	72.0	39.6	49.3	32.9	-0.74	-0.38
MUDDY CREEK AT ARAPAHOE, NE	17.2	6.9	5.3	4.8	-0.24	-0.01
TURKEY CREEK AT EDISON, NE		14.5		11.5		
SAPPA CREEK NR STAMFORD, NE	82.1	5.0	6.8	2.2	-1.77	-0.11
PRAIRIE DOG C NR WOODRUFF, KS	46.8	6.0	3.6	2.9	-0.94	-0.02
CENTER CREEK AT FRANKLIN, NE	6.7	5.9	4.8	4.6	-0.02	0.00
THOMPSON CREEK AT RIVERTON, NE	28.8	24.4	20.2	16.4	-0.10	-0.09
ELM CREEK AT AMBOY, NE	21.3	15.9	15.2	11.4	-0.12	-0.09
Main Stem						
REPUBLICAN RIVER AT STRATTON, NE	155.8	23.5			-3.04	
REPUBLICAN RIVER AT MCCOOK NE	232.7	33.8			-4.57	
REPUBLICAN RIVER AT CAMBRIDGE, NE	343.9	75.2			-6.18	
REPUBLICAN RIVER NR ORLEANS, NE	353.2	61.6			-6.70	
REPUBLICAN RIVER BLW HARLAN COUNTY LAKE, NE	207.6	38.0			-3.90	
REPUBLICAN RIVER AT GUIDE ROCK, NE	471.1	60.5			-9.44	
REPUBLICAN RIVER NR HARDY, NE	556.4	104.1			-10.40	

Table 4.
Average Streamflow and Baseflow for Early and Recent Periods and Trends between Periods (page 2 of 2)

Station & Reach	Average Total Streamflow (cfs)		Average Baseflow (cfs)		Trend between 1950-1967 & 1999-2005 (cfs/yr)	
	1950-1967	1999-2005	1950-1967	1999-2005	Streamflow	Baseflow
Segments						
REPUBLICAN RIVER: STATELINES TO STRATTON	7.2	-18.1	-18.0	-23.3	-0.58	-0.12
FRENCHMAN CREEK: BLW ENDERS TO PALISADE	27.3	17.1	19.5	15.4	-0.23	-0.09
FRENCHMAN CREEK: PALISADE TO CULBERTSON	21.8	3.6	12.8	2.7	-0.42	-0.23
REPUBLICAN RIVER: BLW SWANSON TO MCCOOK	17.6	-0.2	-0.8	-6.0	-0.41	-0.12
REPUBLICAN RIVER: MCCOOK TO CAMBRIDGE	14.1	-2.4	-14.3	-6.6	-0.38	0.18
REPUBLICAN RIVER: CAMBRIDGE TO ORLEANS	37.8	14.6	-7.0	5.0	-0.53	0.28
REPUBLICAN RIVER: BLW HARLAN CO LK TO GUIDE ROCK	119.9	107.8	54.0	75.3	-0.28	0.49
REPUBLICAN RIVER: GUIDE ROCK TO HARDY	62.1	43.7	10.8	25.0	-0.42	0.33

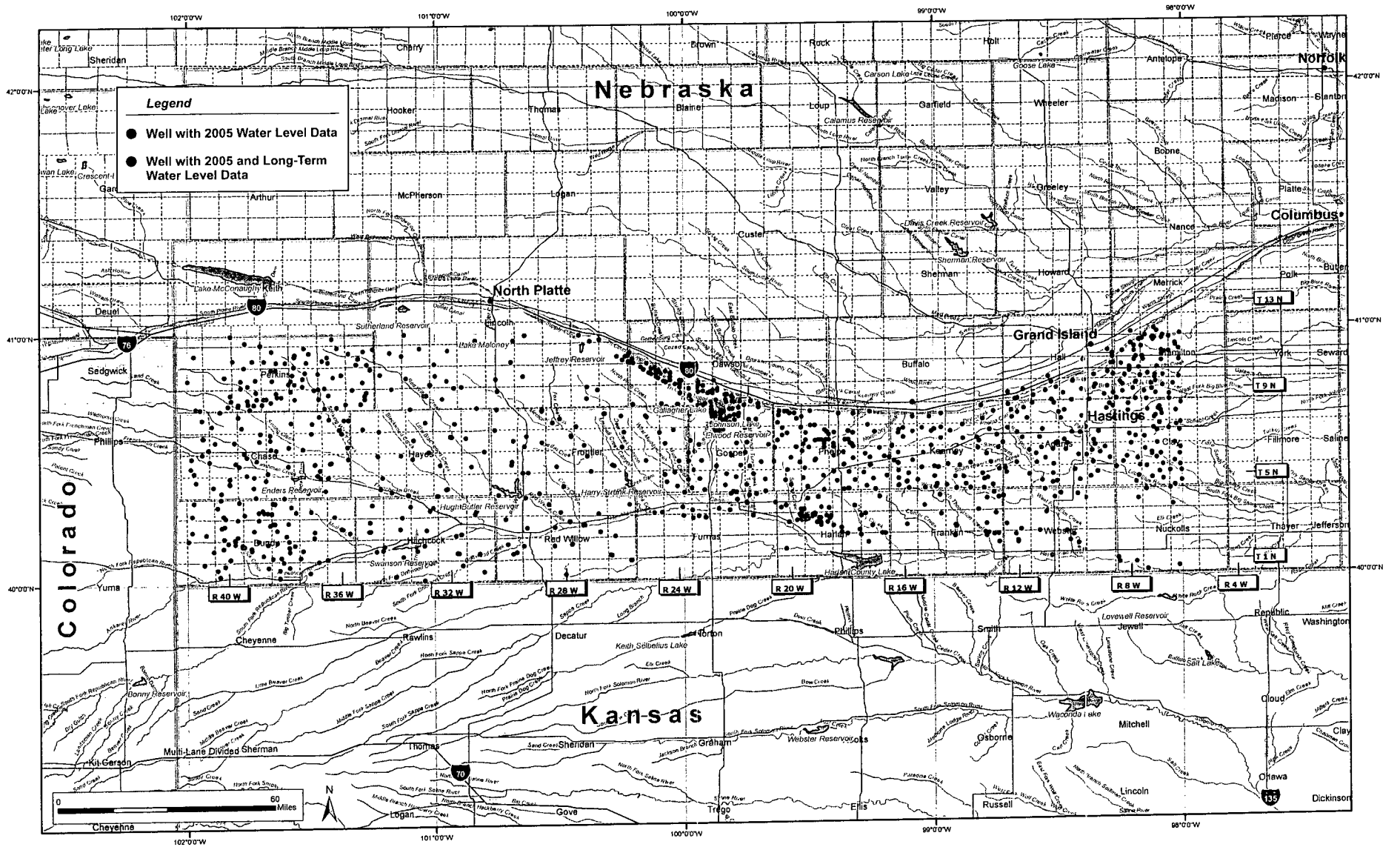


Figure 1. Location of Wells with Data for 2005 Water Level Map and Historical Conditions

DNR 008975

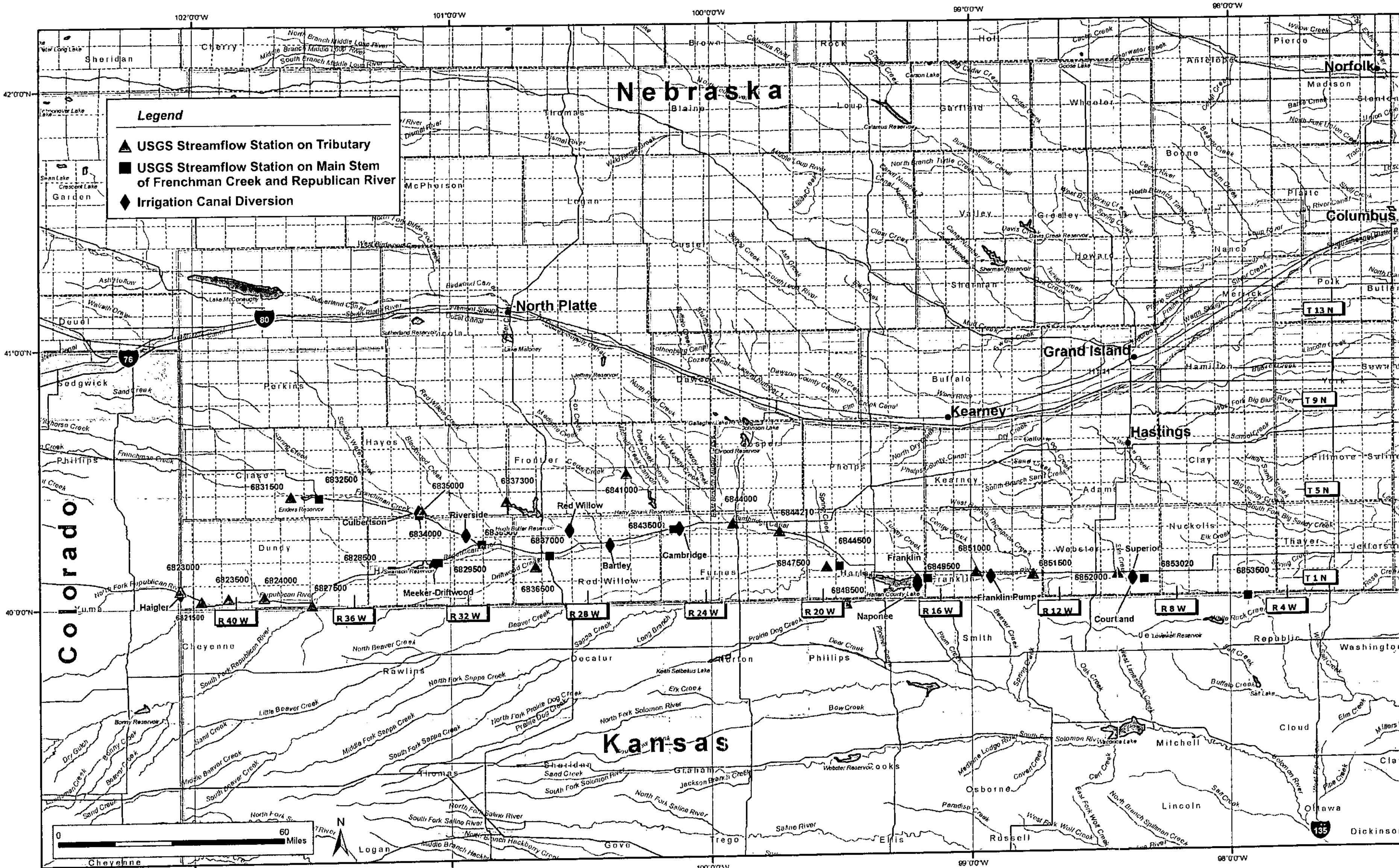


Figure 2. Locations of Streamflow Gaging Stations and Major Canal Diversions

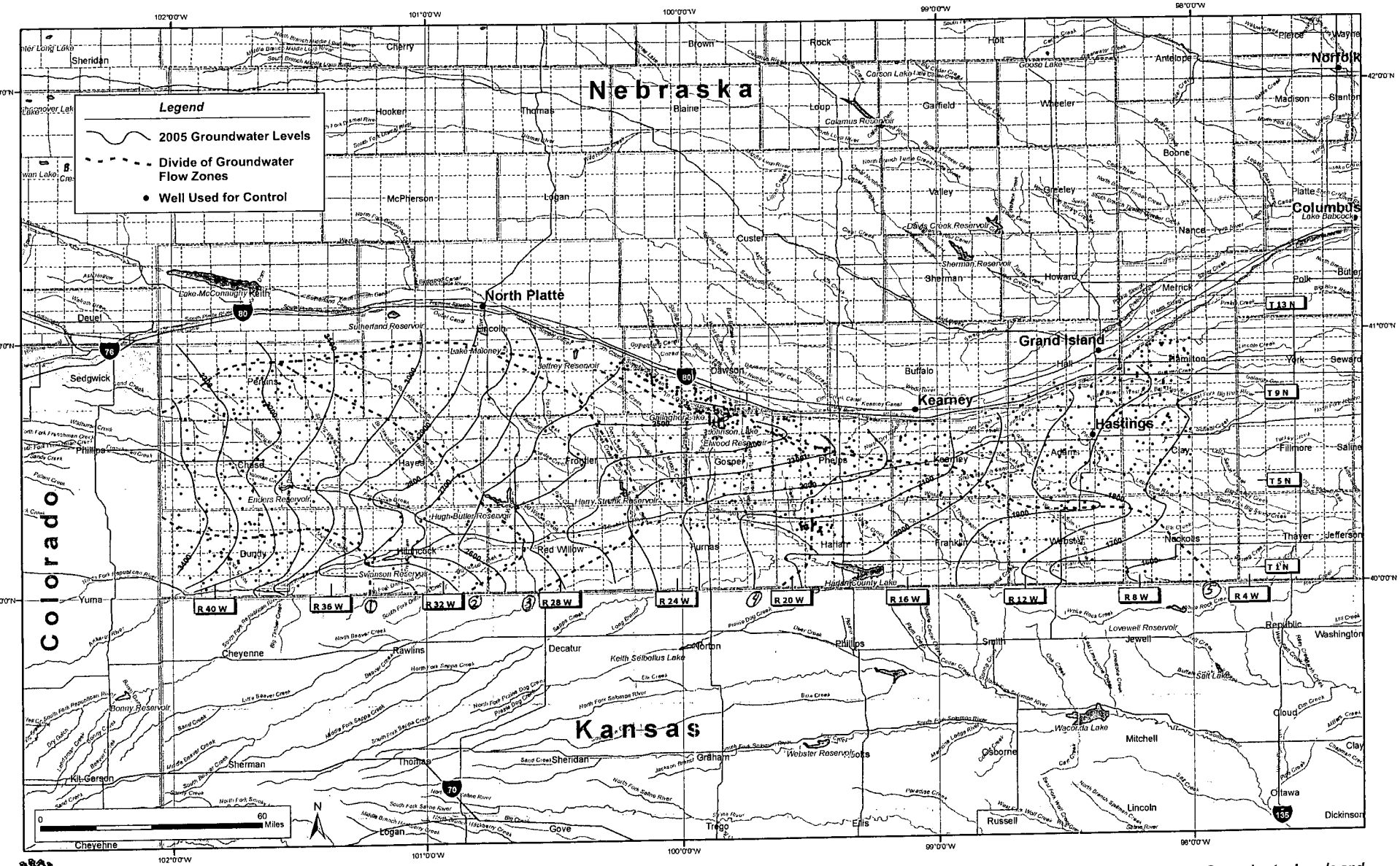


Figure 3. 2005 Groundwater Levels and Flow Zones

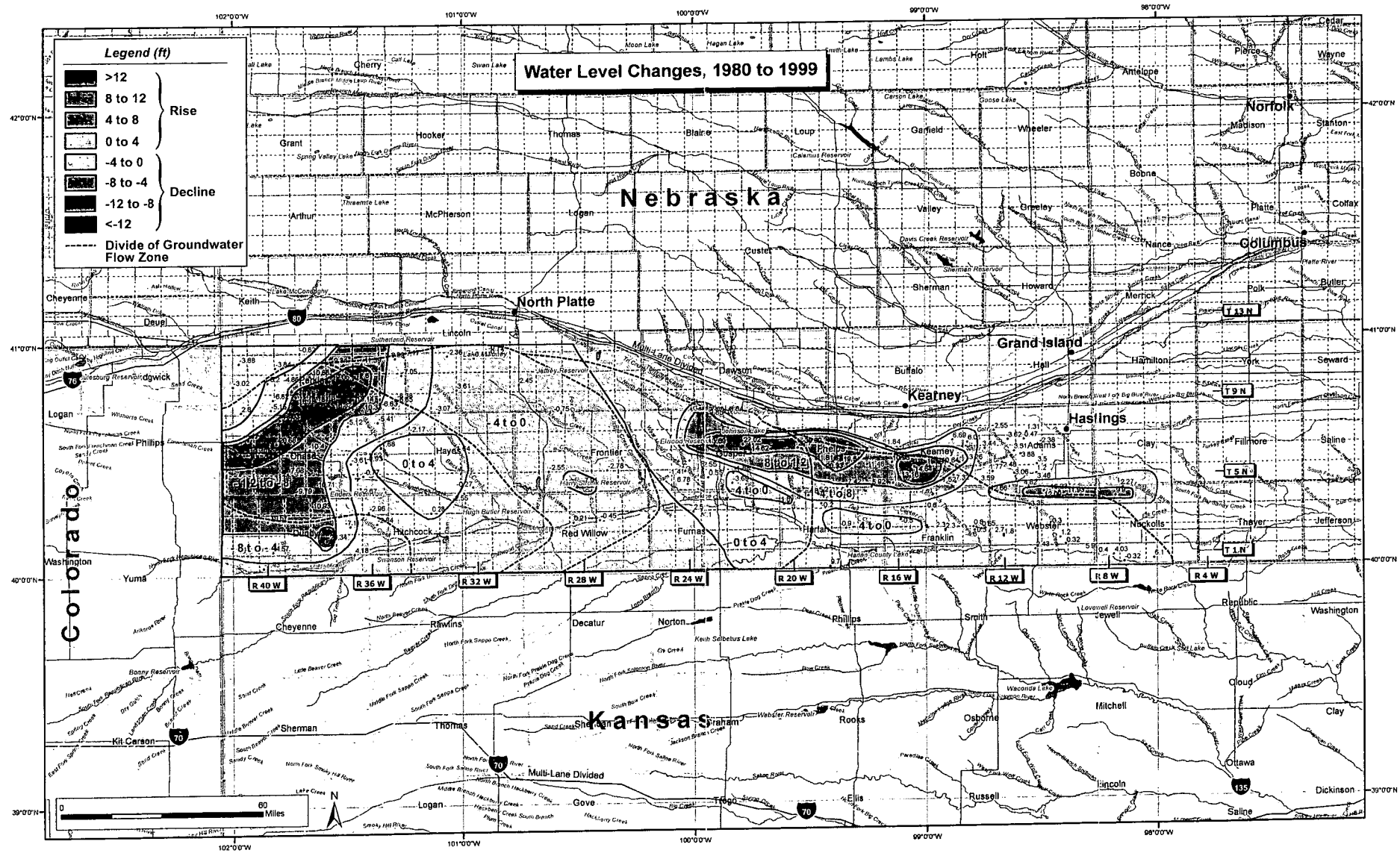


Figure 4. Change in Groundwater Level from 1980 to 1999

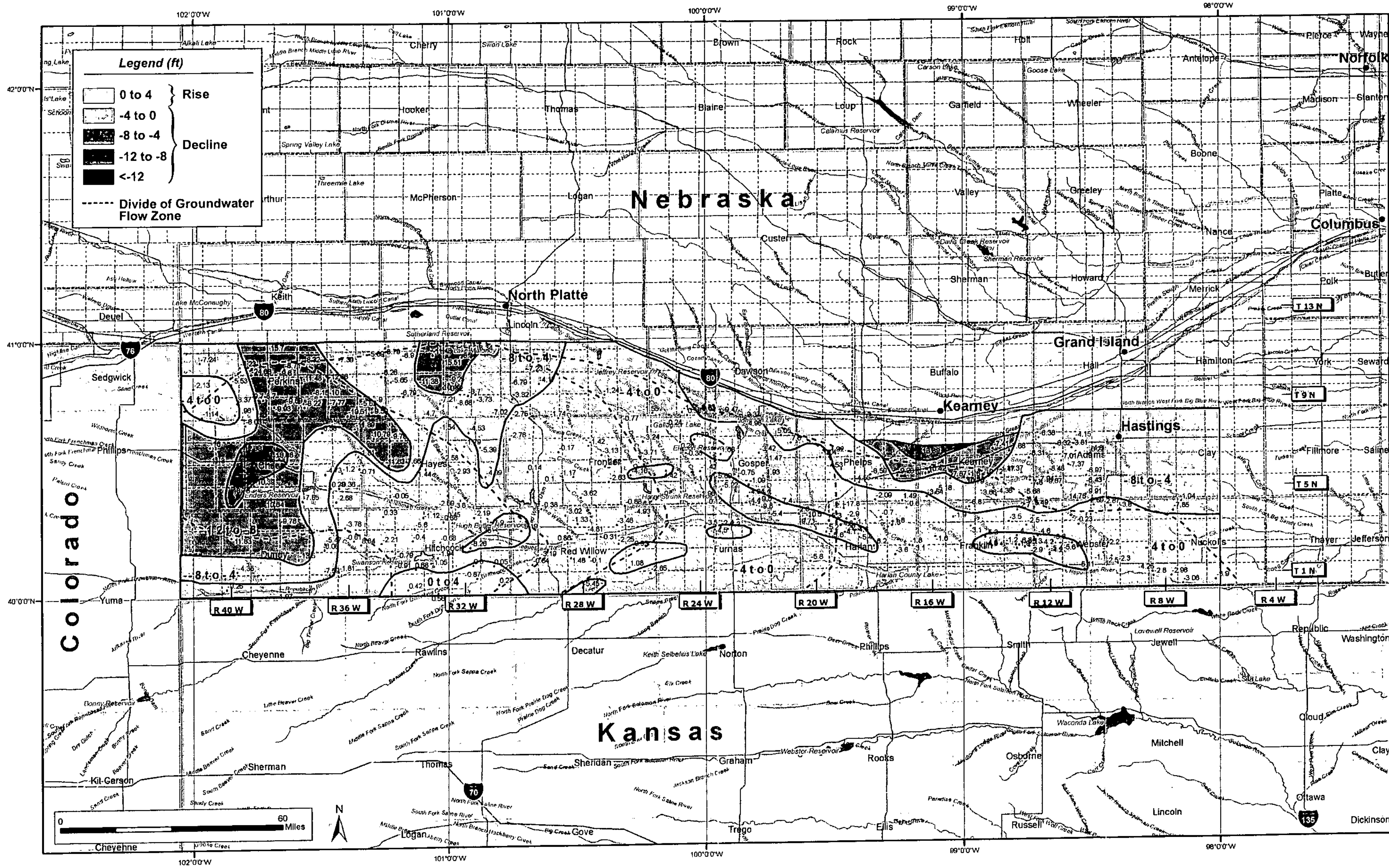
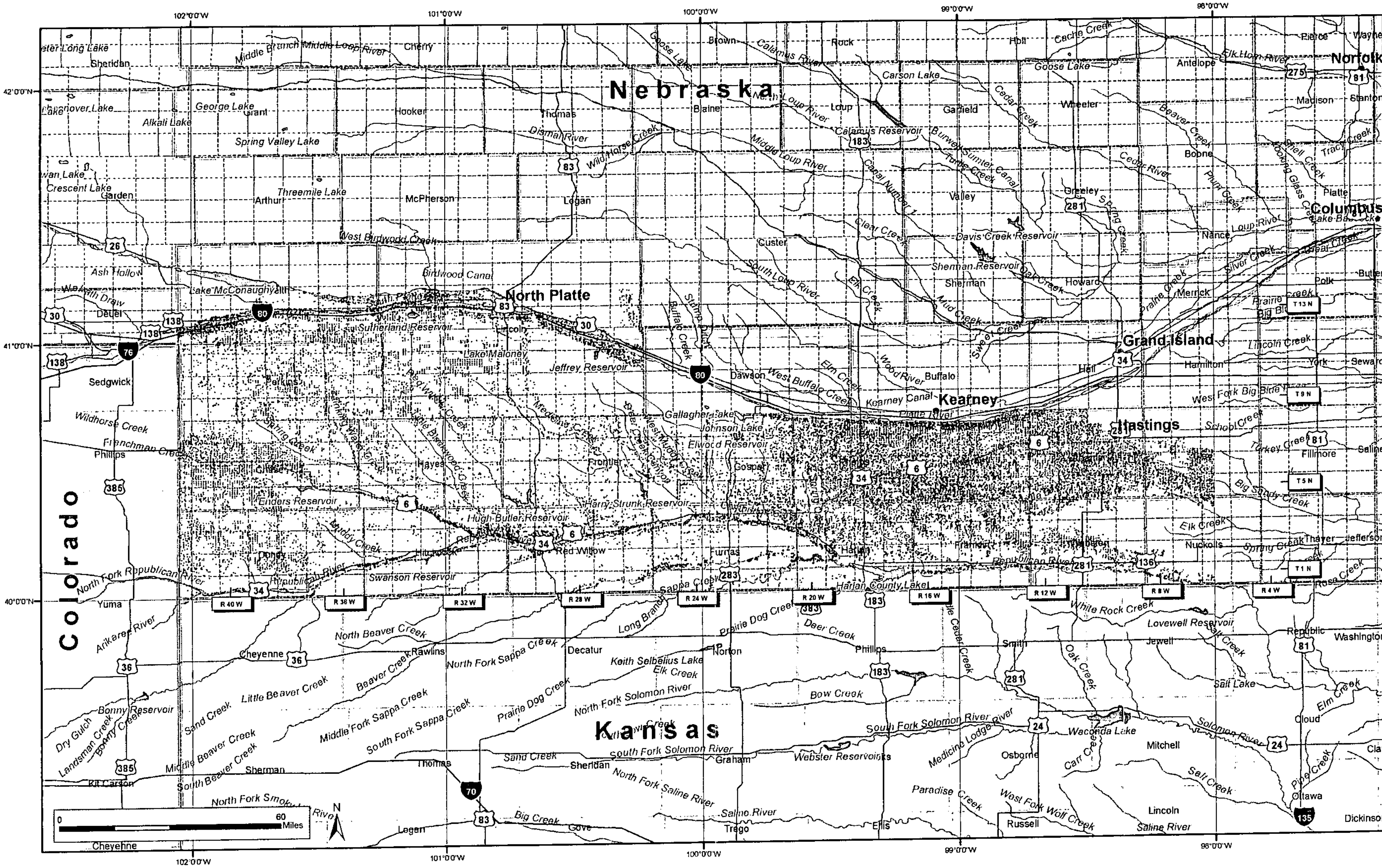


Figure 5. Change in Groundwater Level from 1999 to 2005

HDR



HDR

Figure 6. Locations of Registered Irrigation Wells

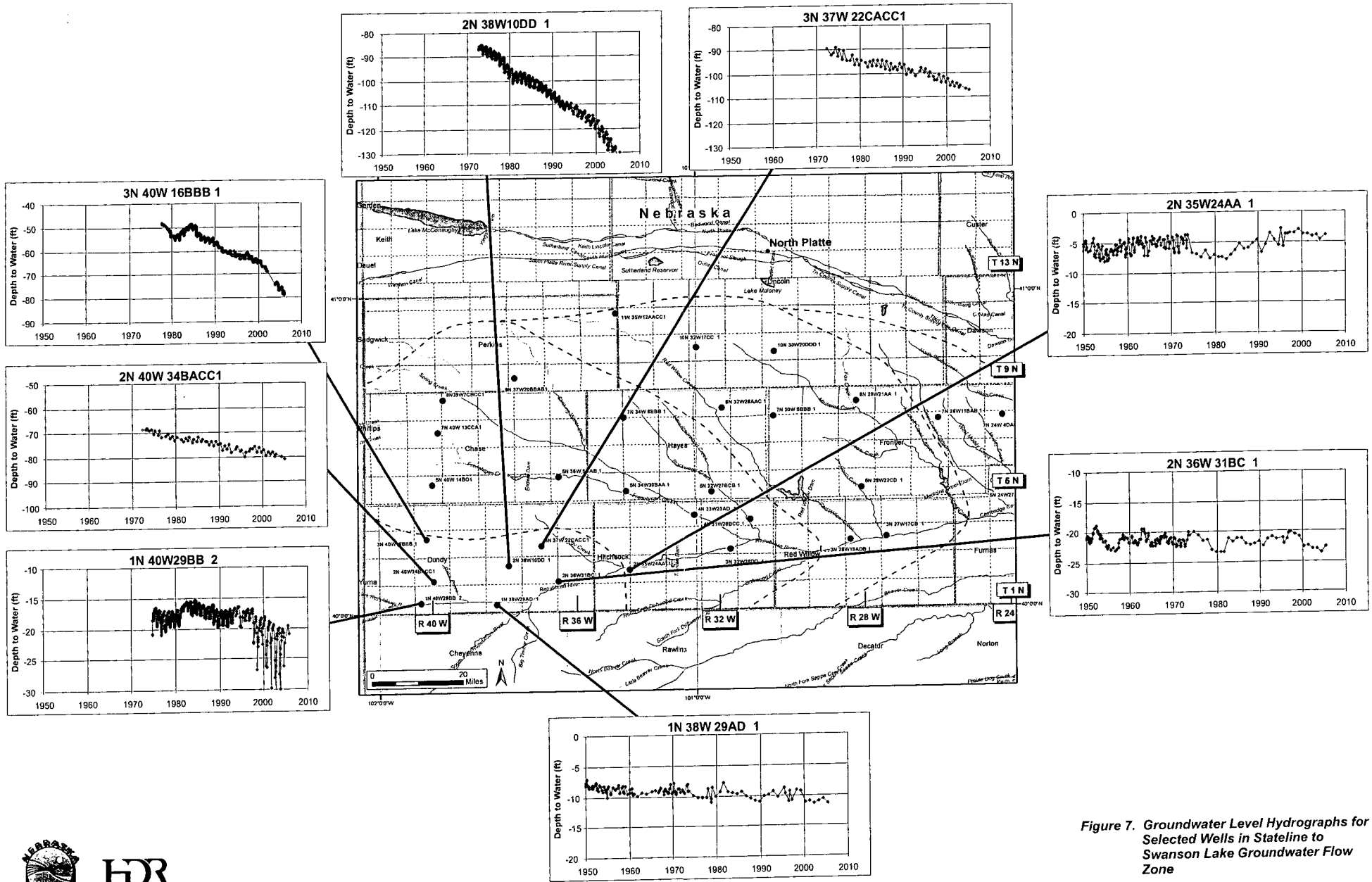


Figure 7. Groundwater Level Hydrographs for Selected Wells in Stateline to Swanson Lake Groundwater Flow Zone

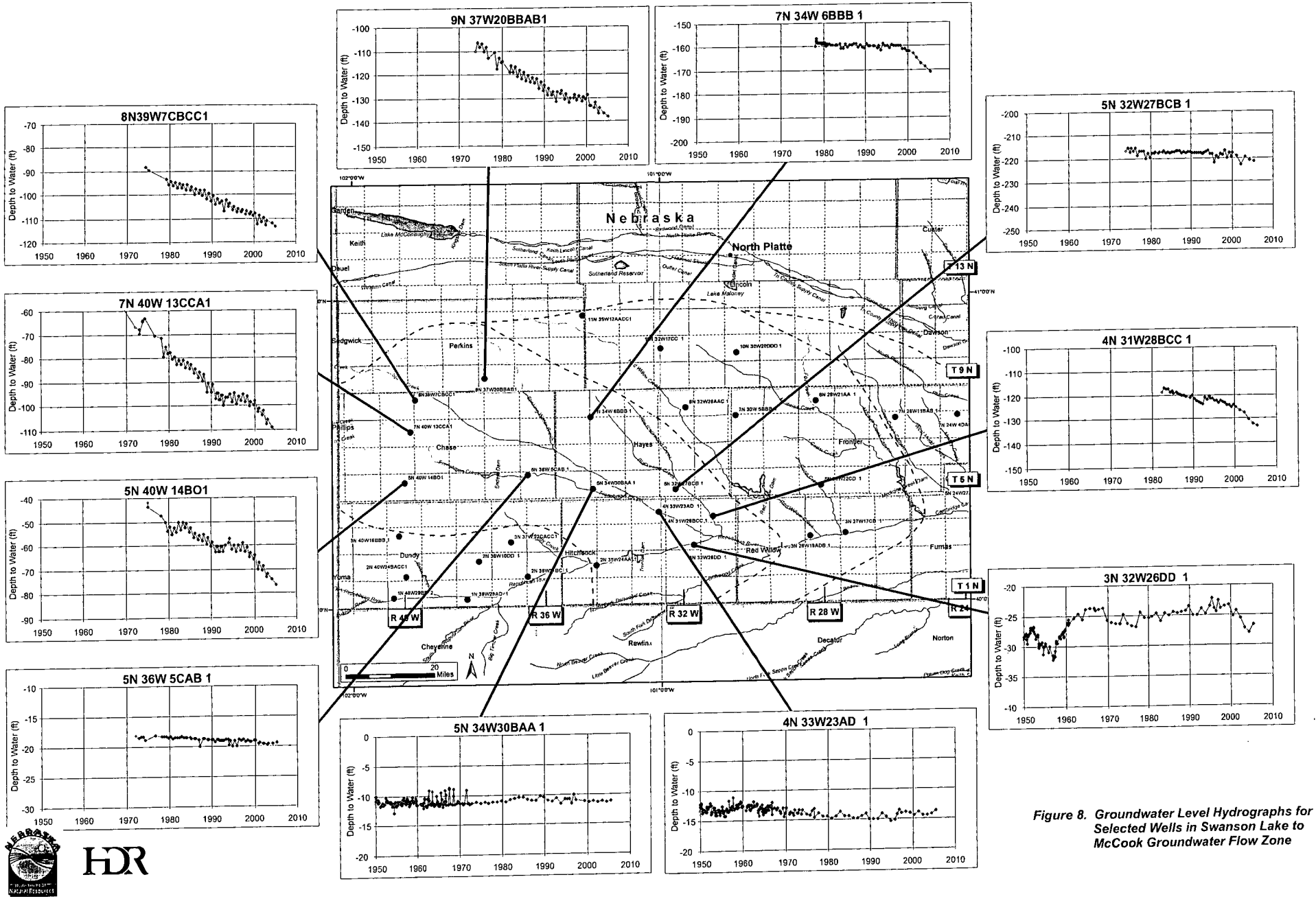


Figure 8. Groundwater Level Hydrographs for Selected Wells in Swanson Lake to McCook Groundwater Flow Zone

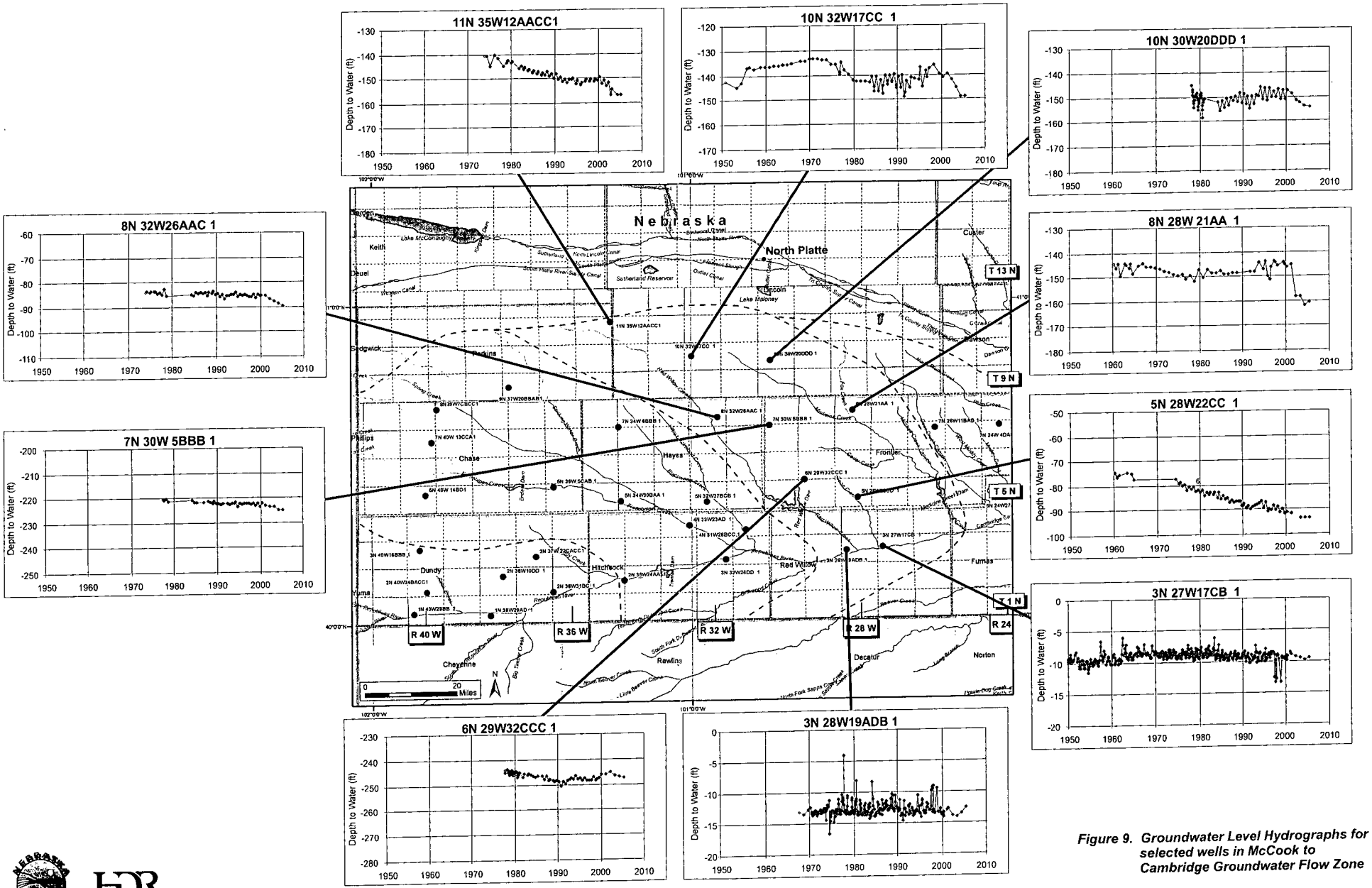


Figure 9. Groundwater Level Hydrographs for selected wells in McCook to Cambridge Groundwater Flow Zone

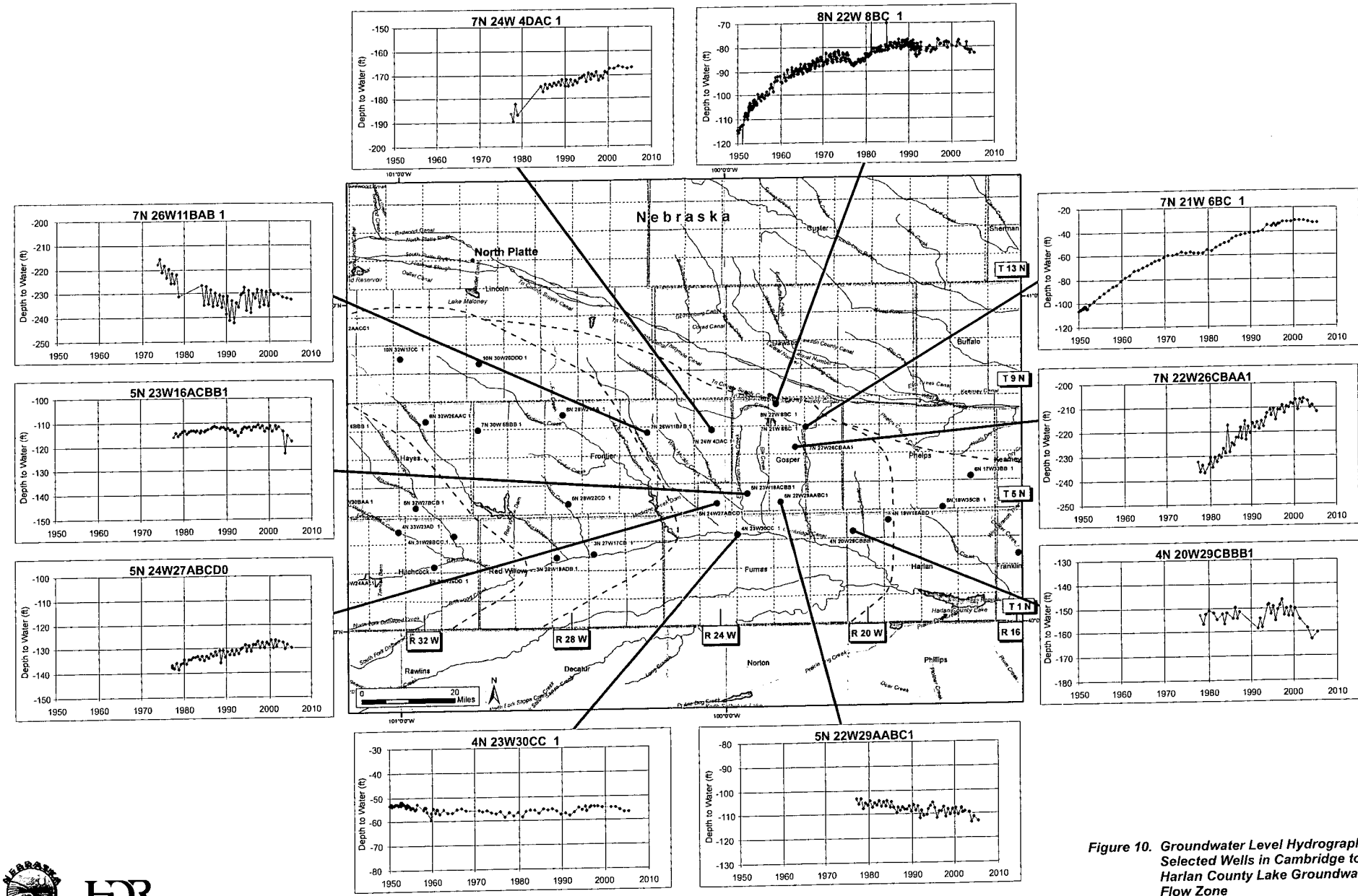


Figure 10. Groundwater Level Hydrographs for Selected Wells in Cambridge to Harlan County Lake Groundwater Flow Zone

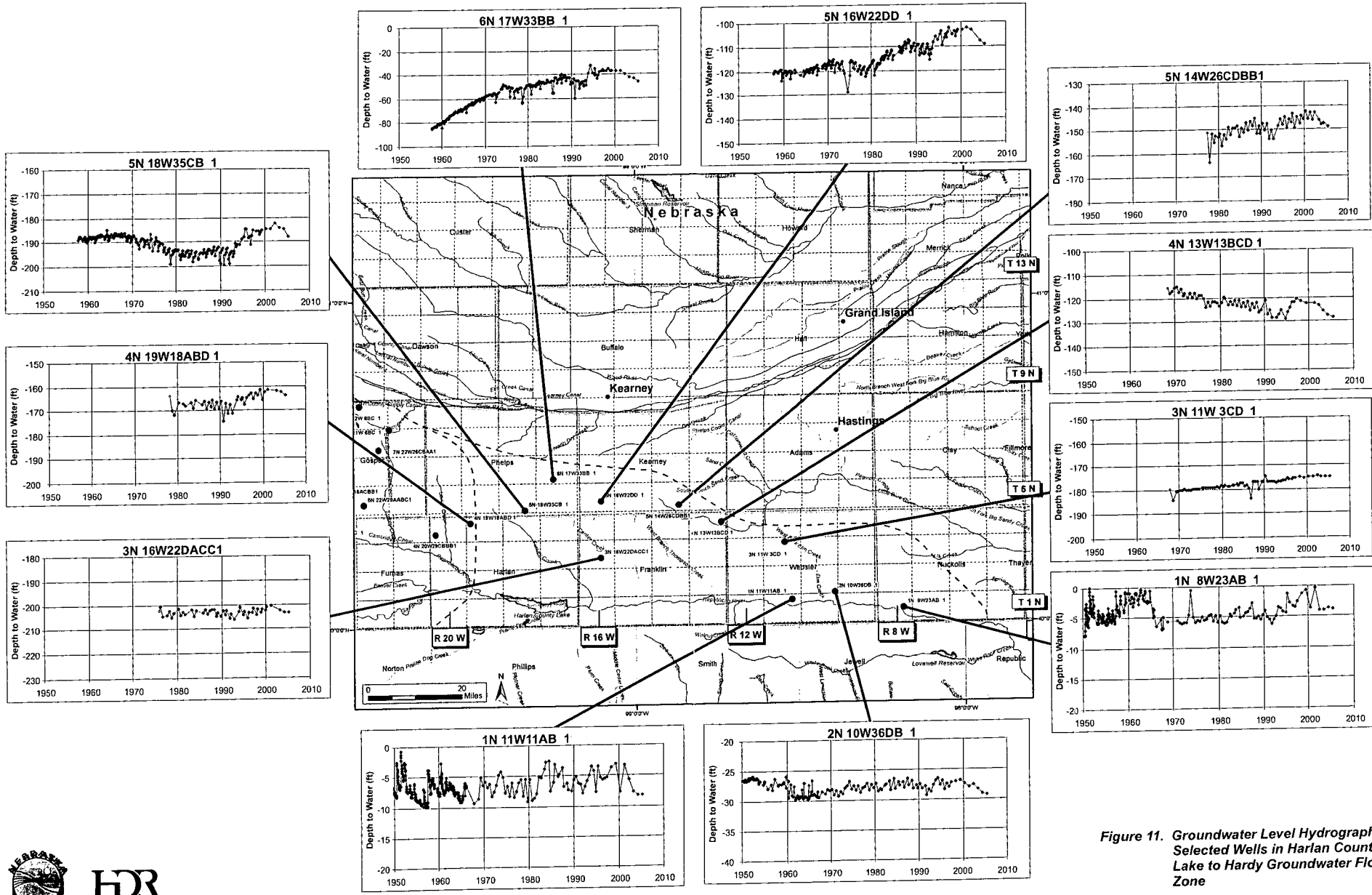


Figure 11. Groundwater Level Hydrographs for Selected Wells in Harlan County Lake to Hardy Groundwater Flow Zone

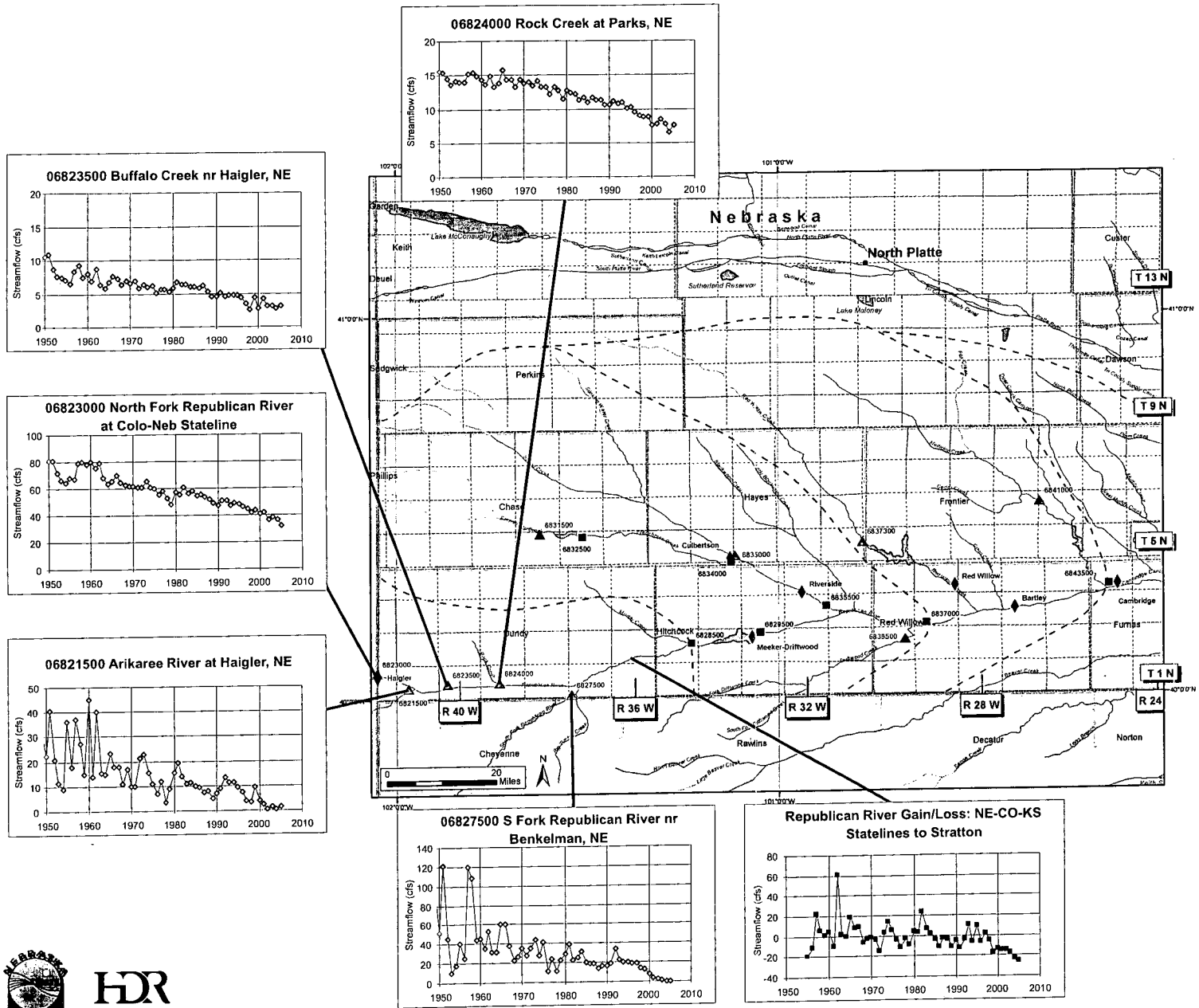


Figure 12. Total Streamflow Hydrographs for Tributaries and Main Stem Reach in Stateline to Swanson Lake Groundwater Flow Zone

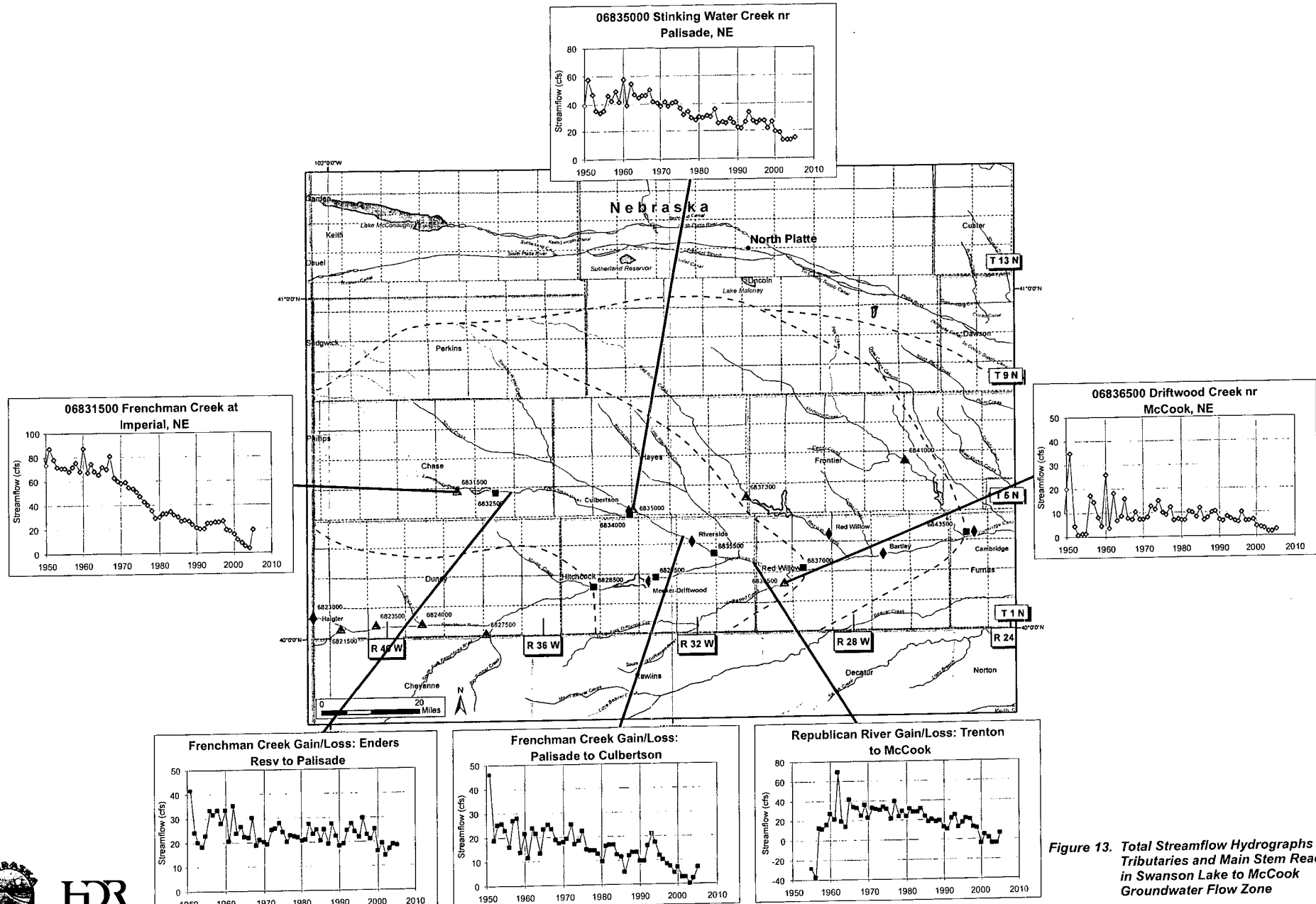


Figure 13. Total Streamflow Hydrographs for Tributaries and Main Stem Reaches in Swanson Lake to McCook Groundwater Flow Zone

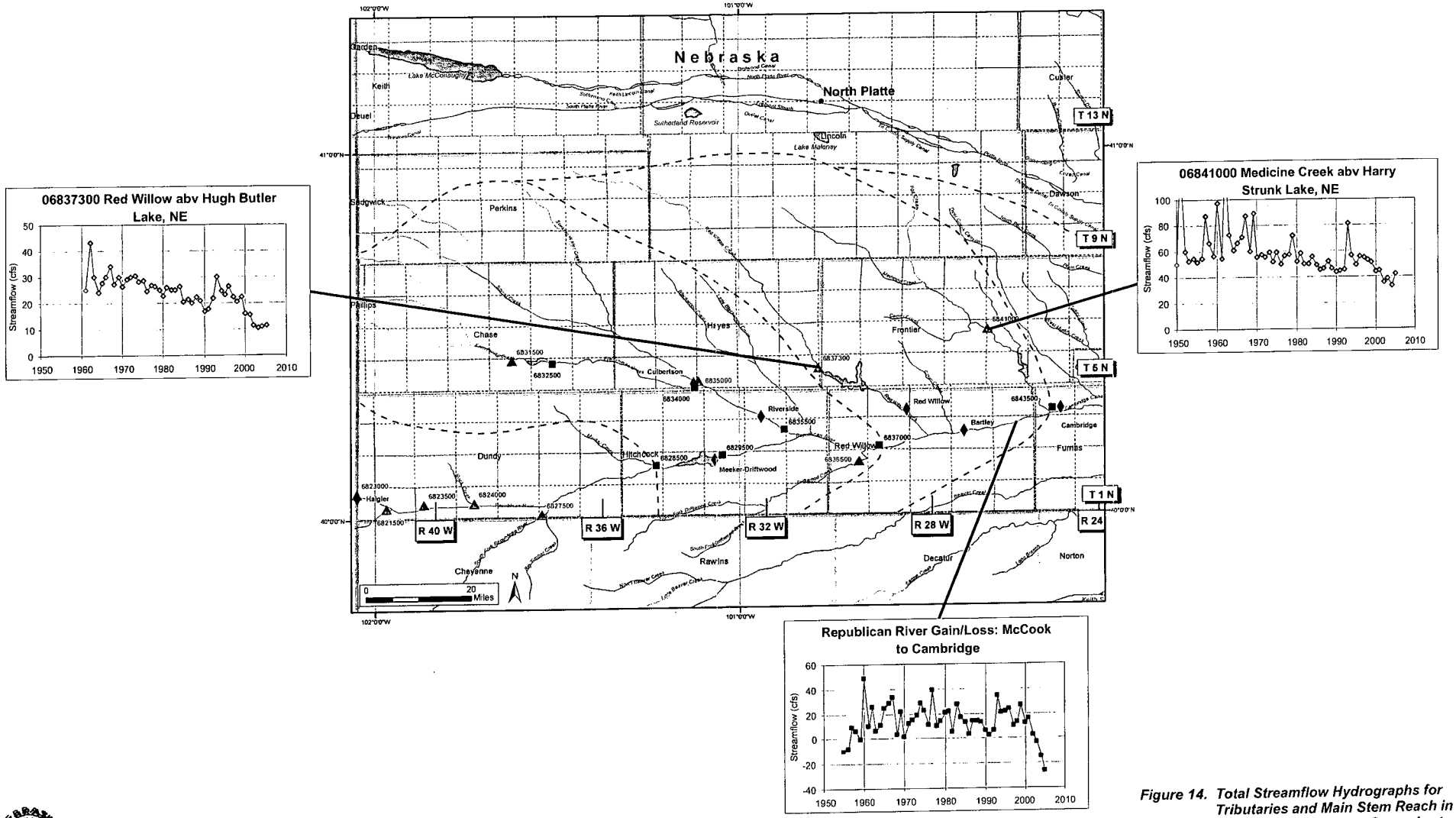


Figure 14. Total Streamflow Hydrographs for Tributaries and Main Stem Reach in McCook to Cambridge Groundwater Flow Zone

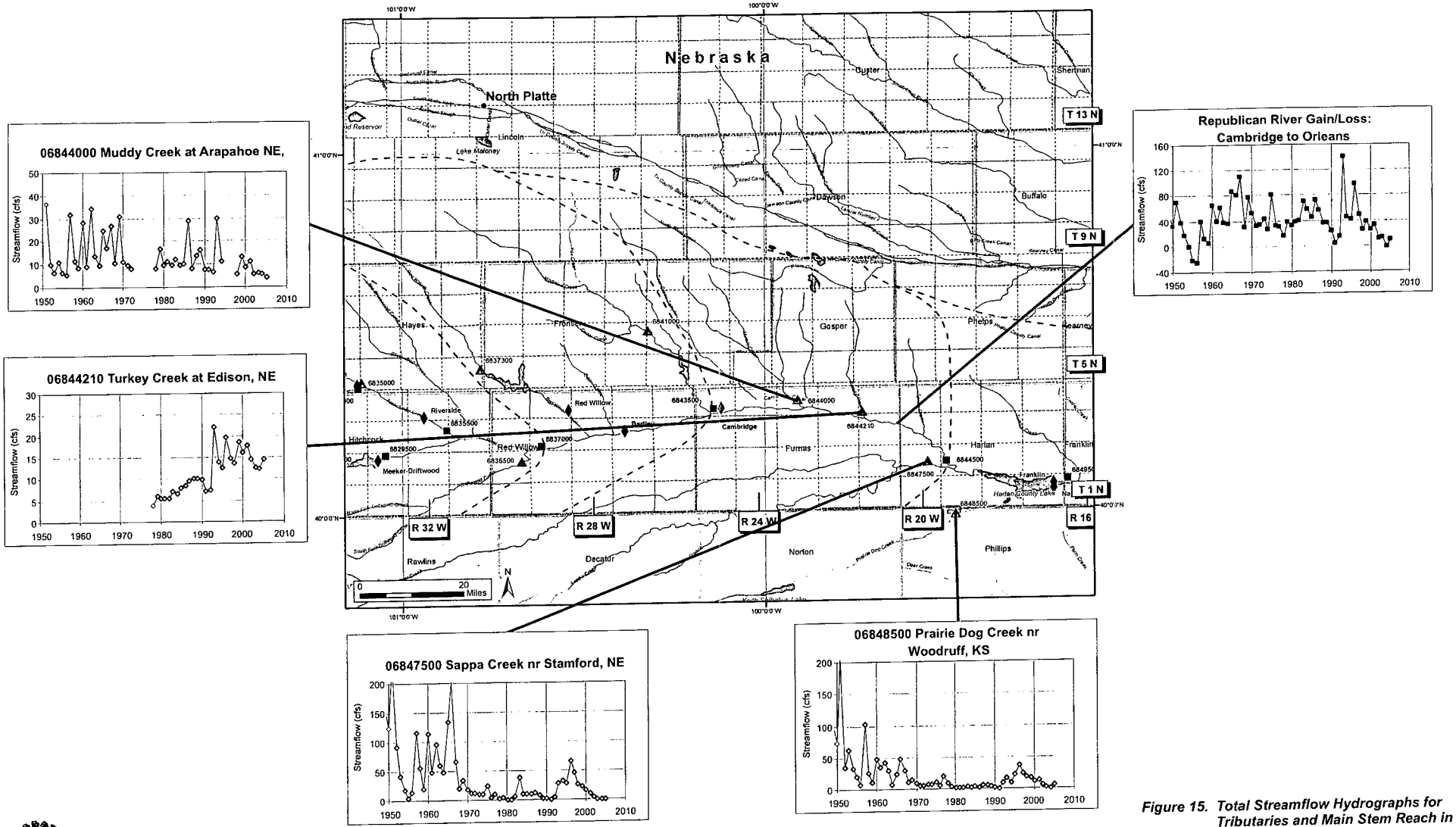


Figure 15. Total Streamflow Hydrographs for Tributaries and Main Stem Reach in Cambridge to Harlan County Lake Groundwater Flow Zone

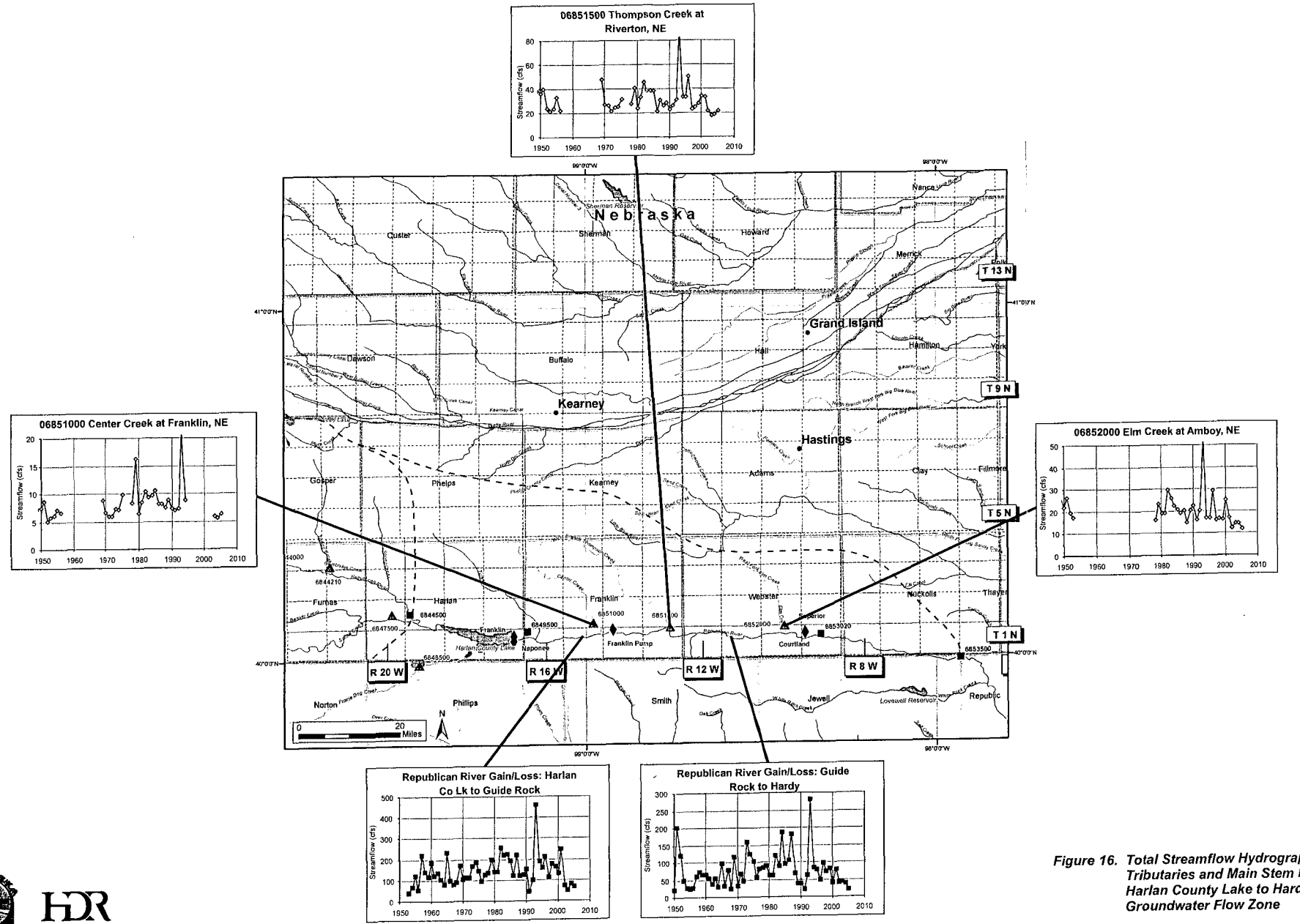


Figure 16. Total Streamflow Hydrographs for Tributaries and Main Stem Reach in Harlan County Lake to Hardy Groundwater Flow Zone

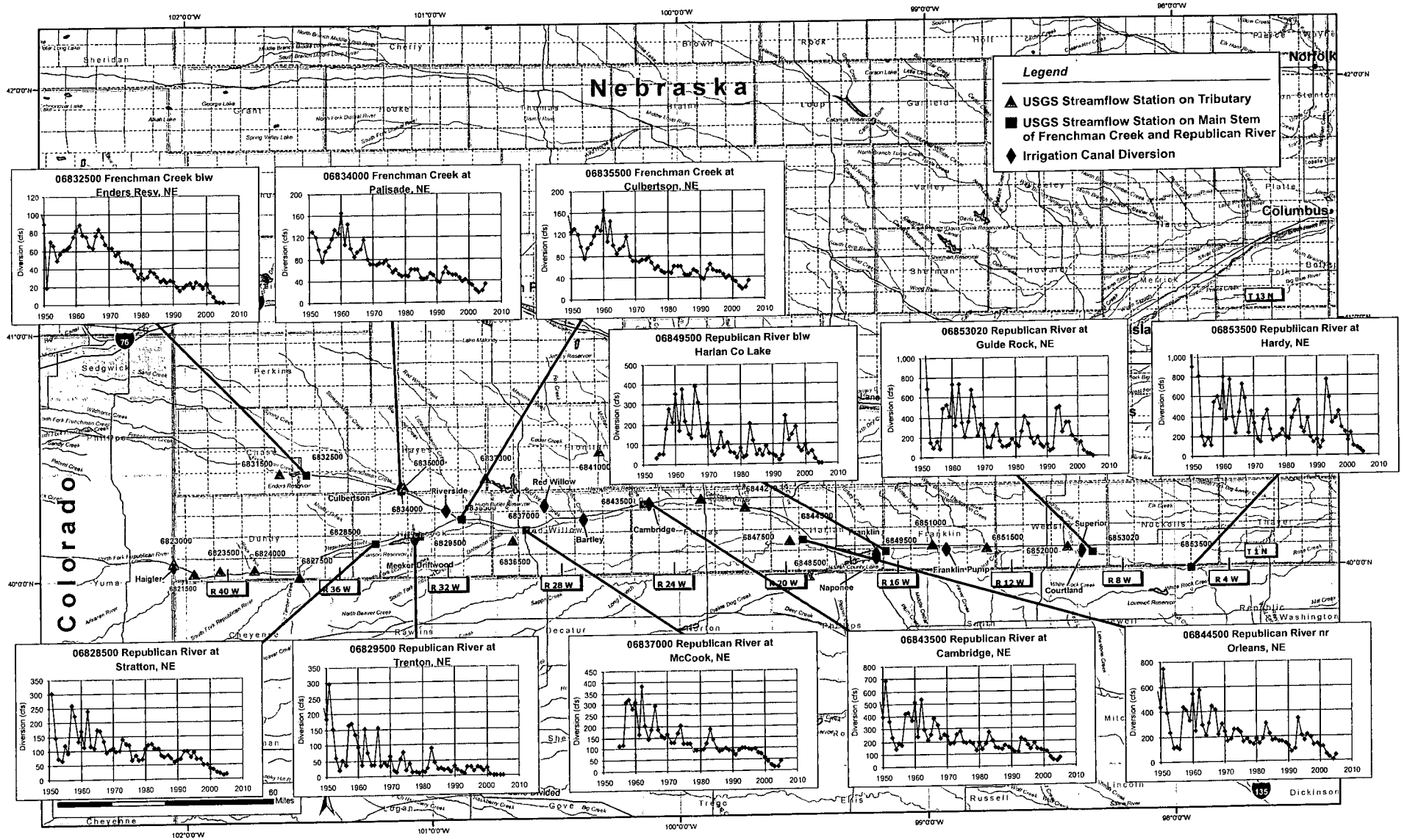


Figure 17. Streamflow at Main Stem Stations on Republican River and French Creek

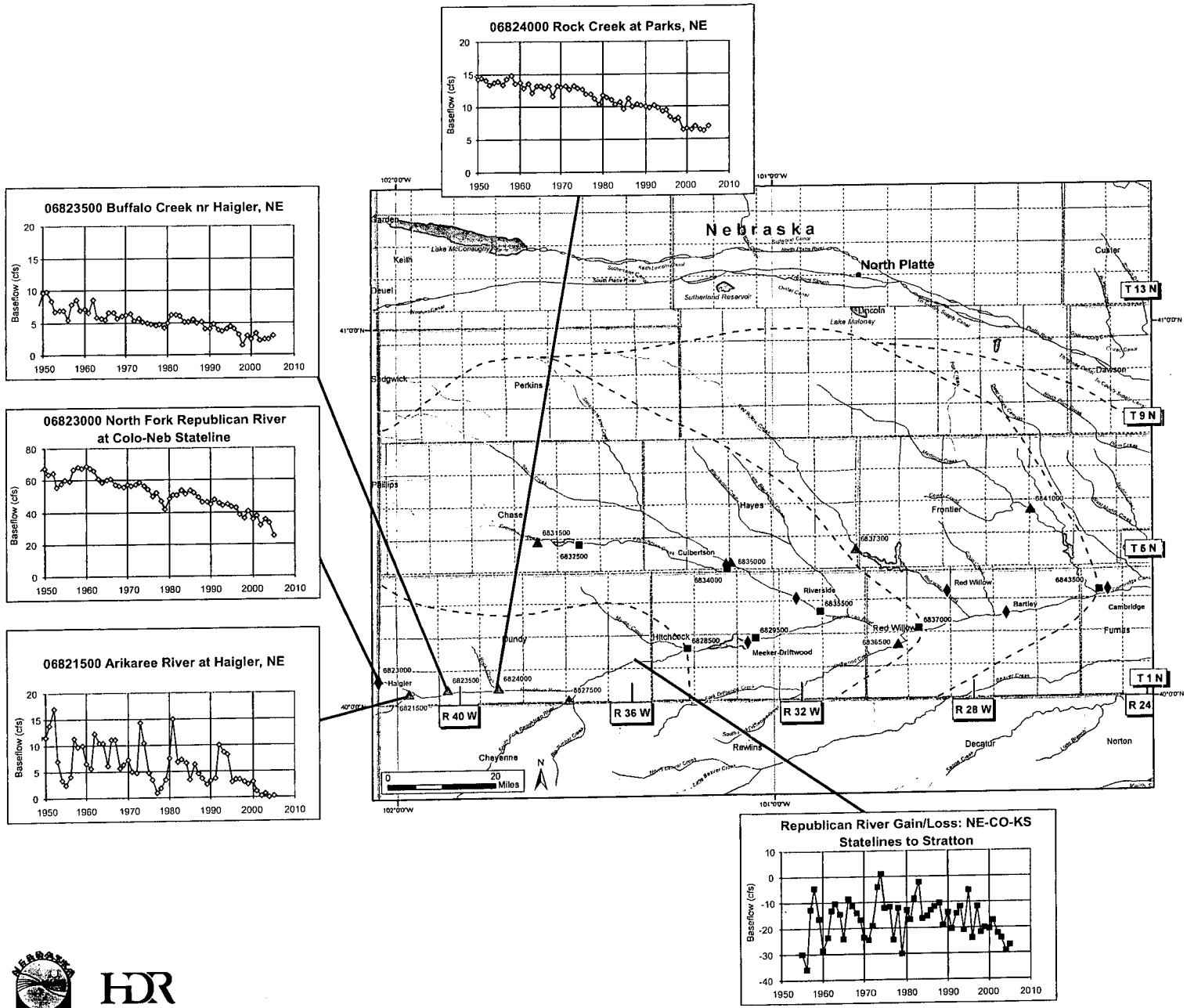


Figure 18. Baseflow Hydrographs for Tributaries and Main Stem Reach in Stateline to Swanson Lake Groundwater Flow Zone

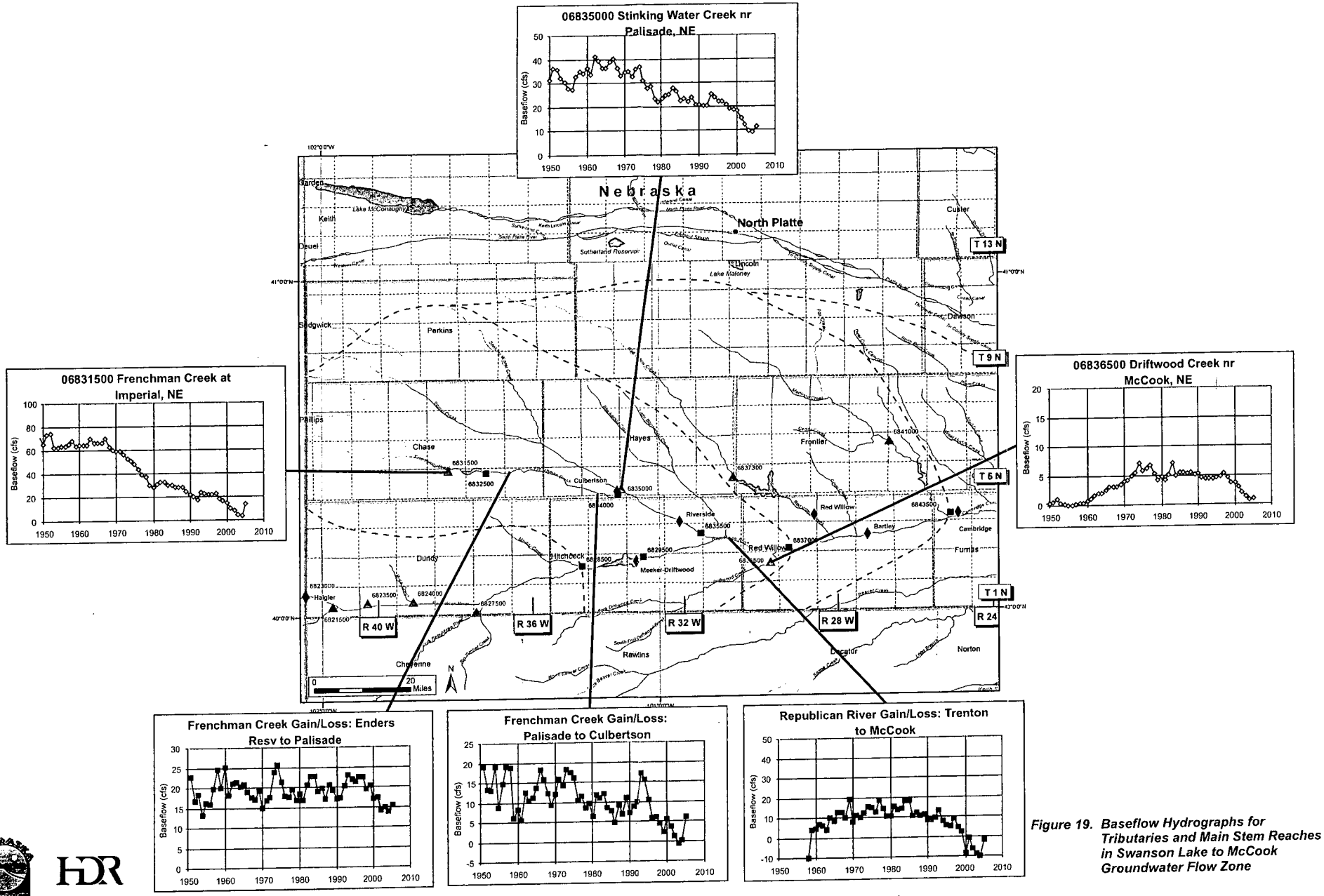


Figure 19. Baseflow Hydrographs for Tributaries and Main Stem Reaches in Swanson Lake to McCook Groundwater Flow Zone

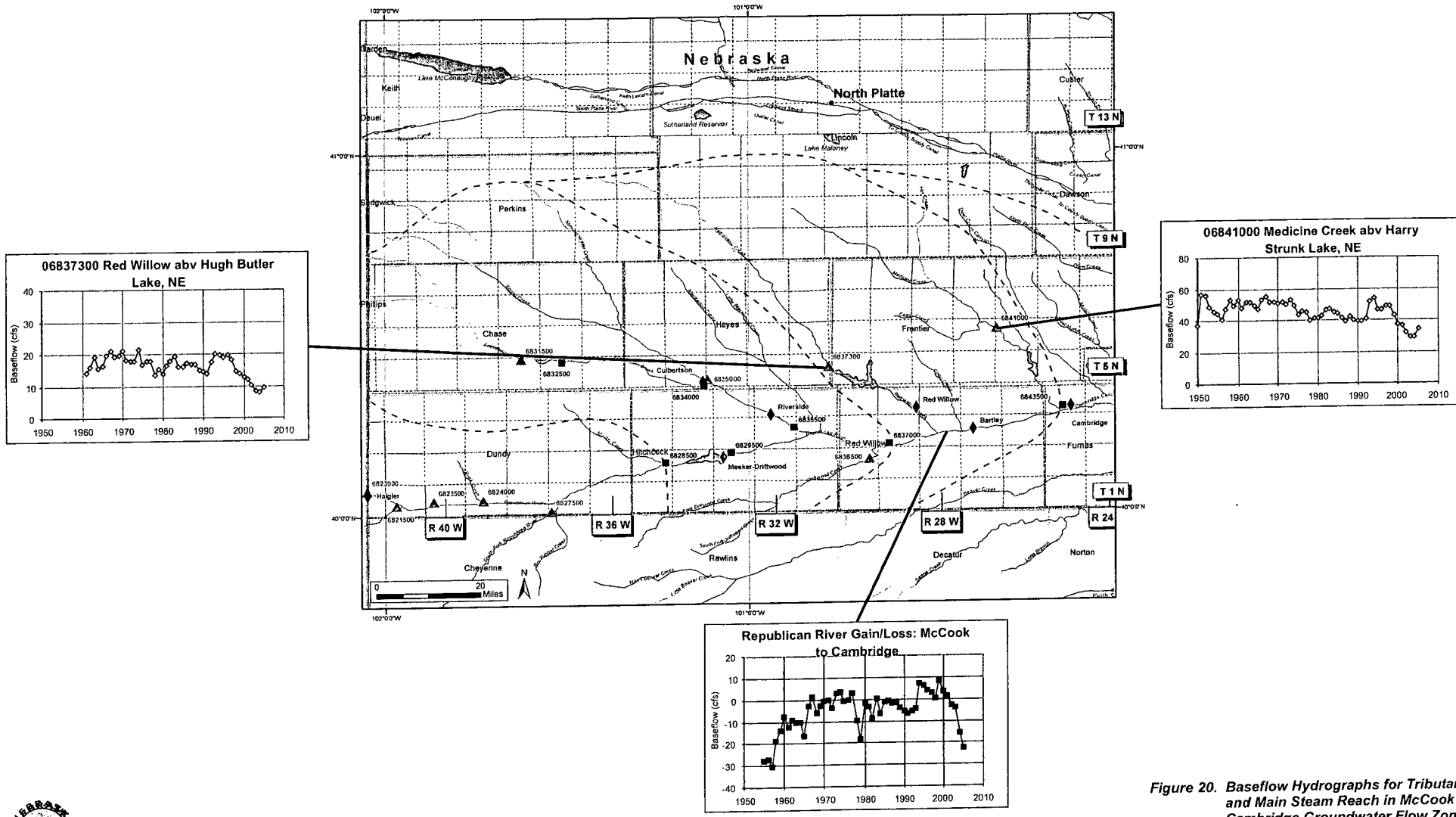


Figure 20. Baseflow Hydrographs for Tributaries and Main Steam Reach in McCook to Cambridge Groundwater Flow Zone

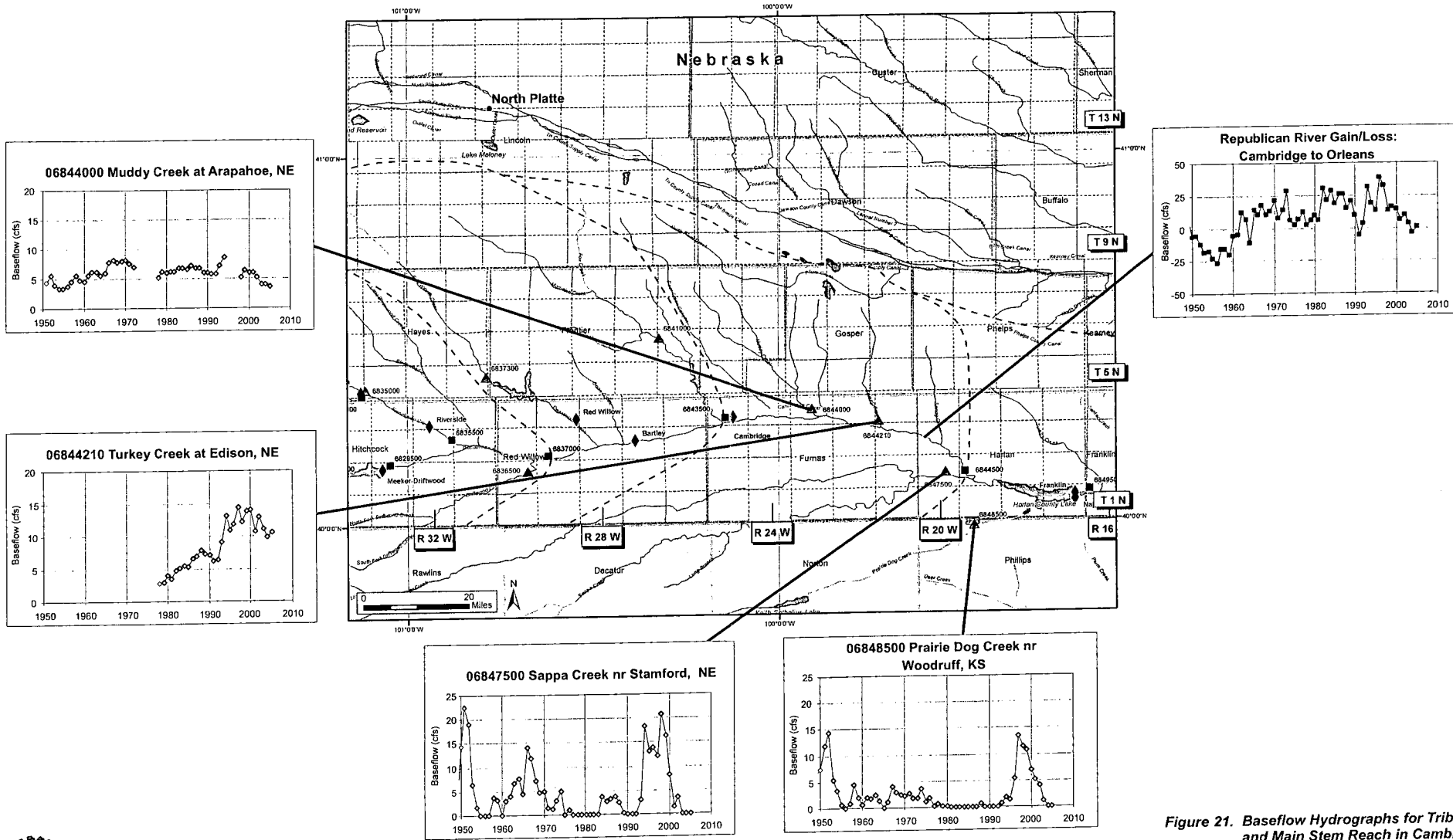


Figure 21. Baseflow Hydrographs for Tributaries and Main Stem Reach in Cambridge to Harlan County Lake Groundwater Flow Zone

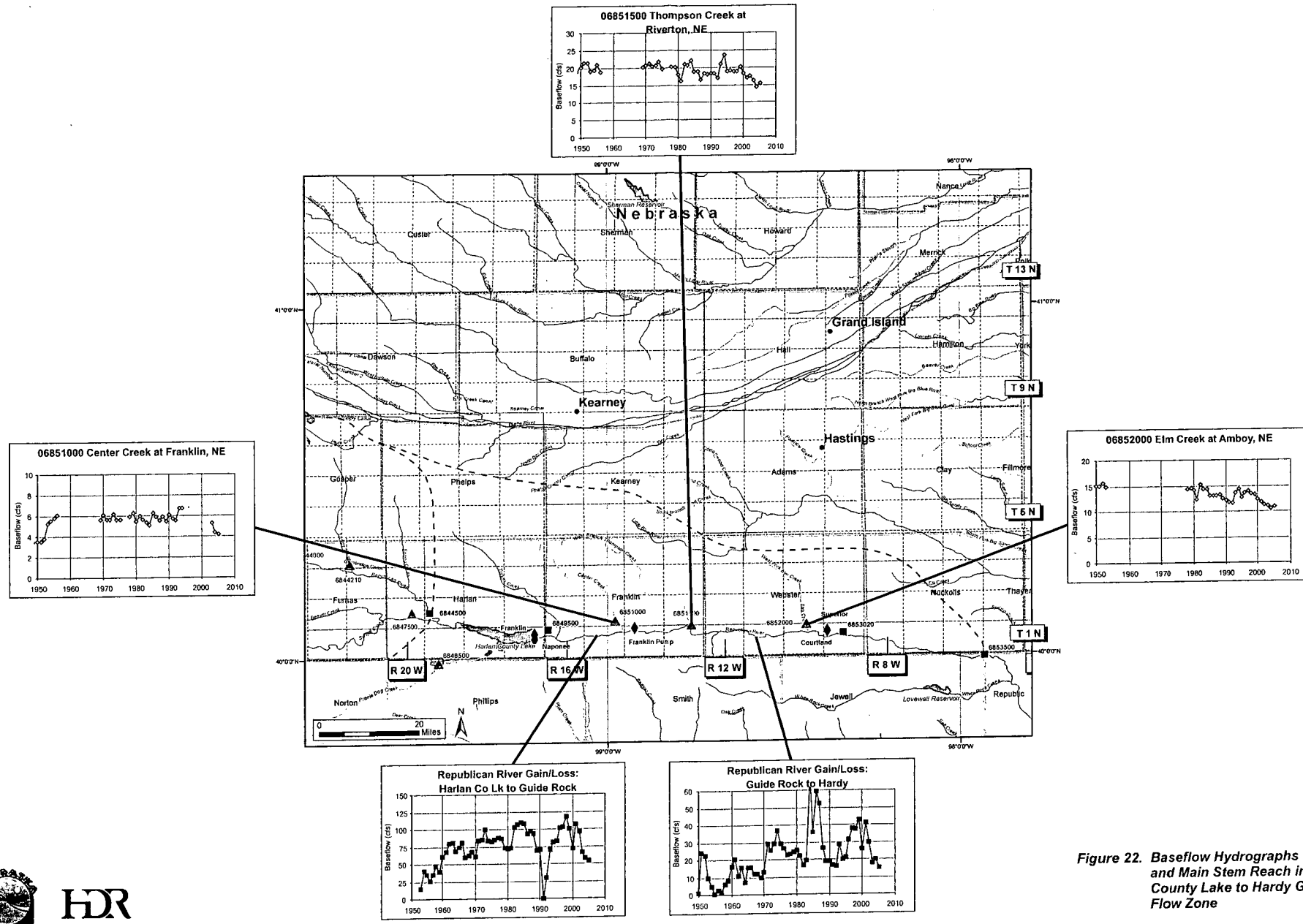


Figure 22. Baseflow Hydrographs for Tributaries and Main Stem Reach in Harlan County Lake to Hardy Groundwater Flow Zone

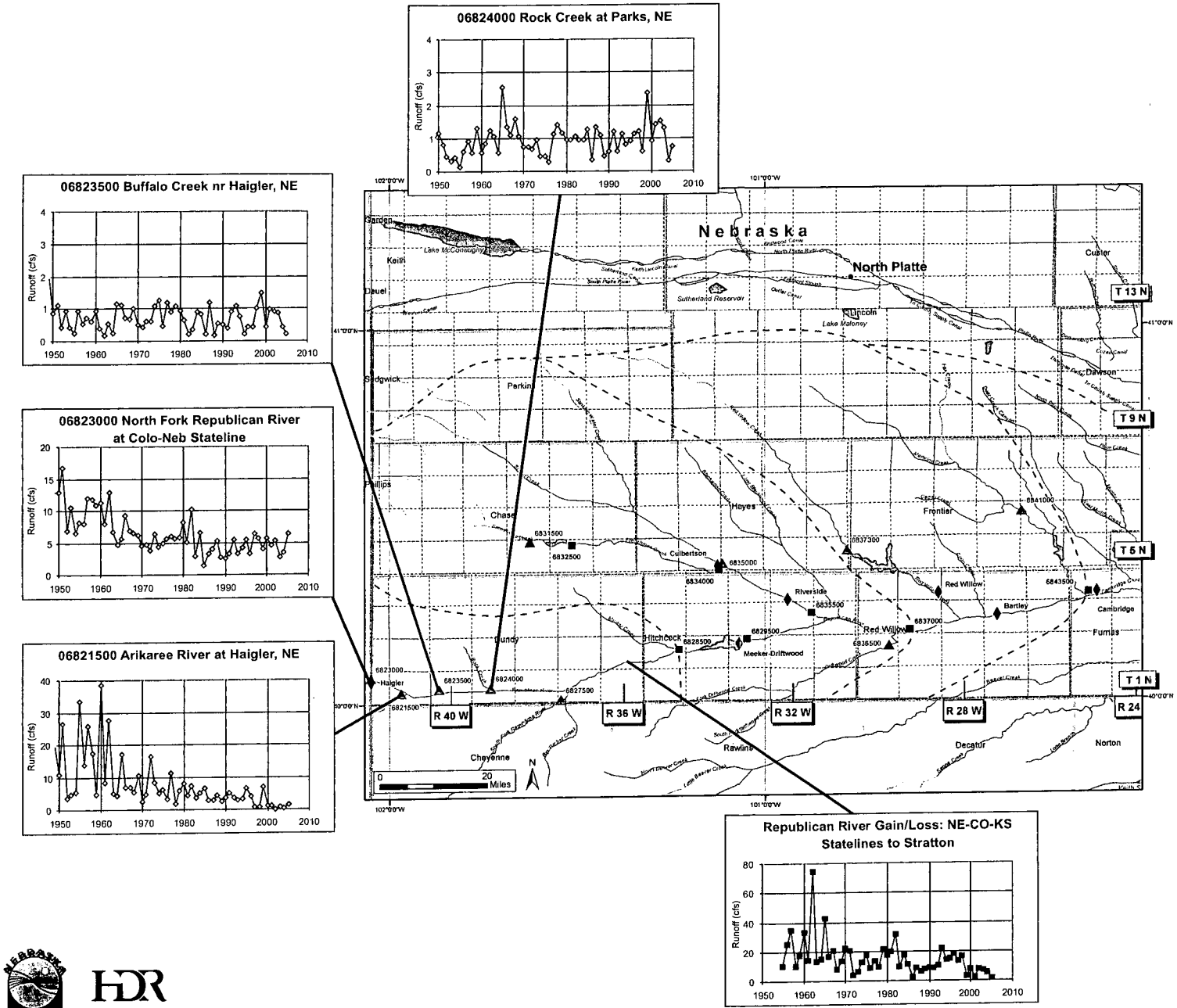


Figure 23. Runoff Hydrographs for Tributaries and Main Steam Reach in Stateline to Swanson Lake Groundwater Flow Zone

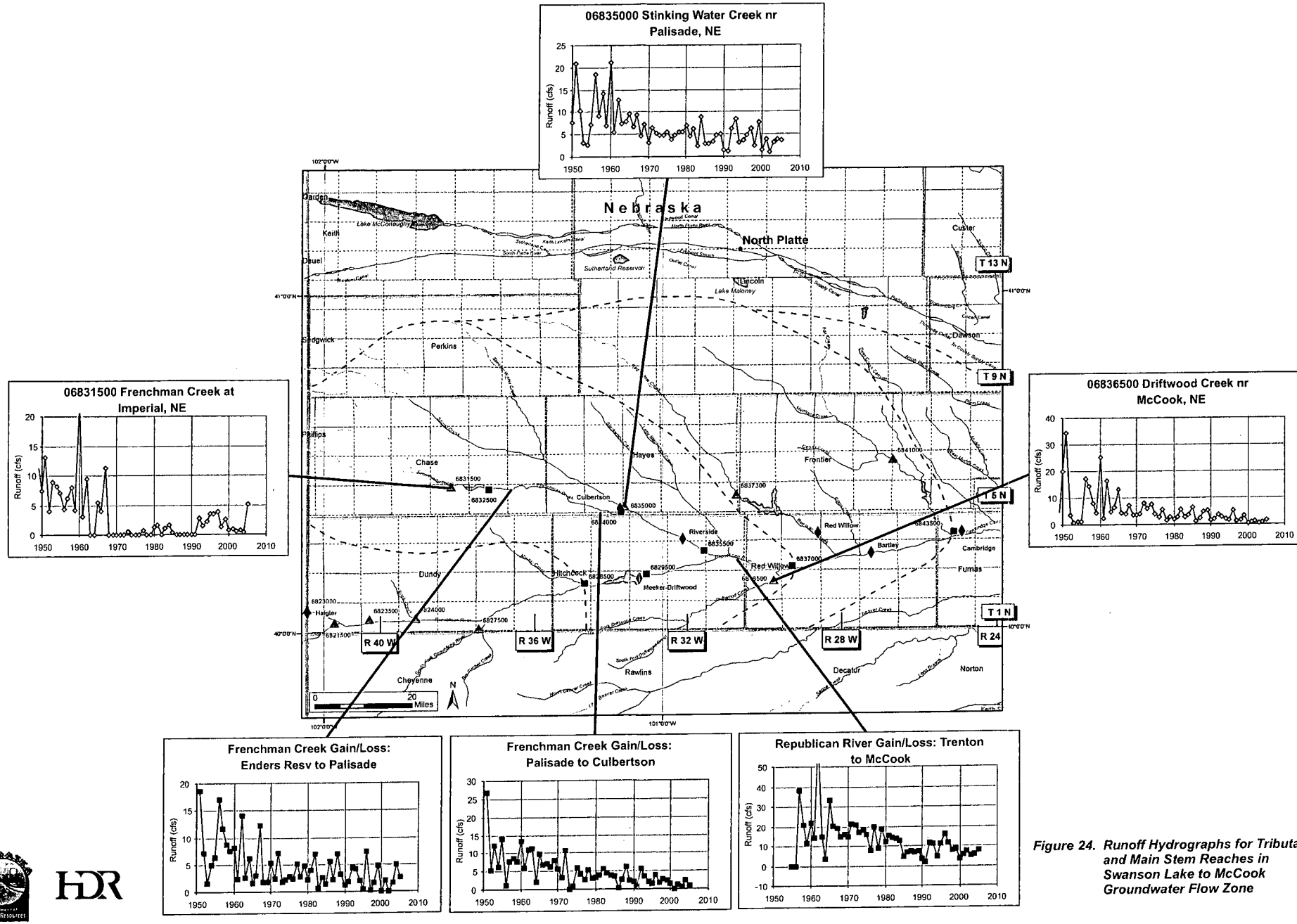


Figure 24. Runoff Hydrographs for Tributaries and Main Stem Reaches in Swanson Lake to McCook Groundwater Flow Zone

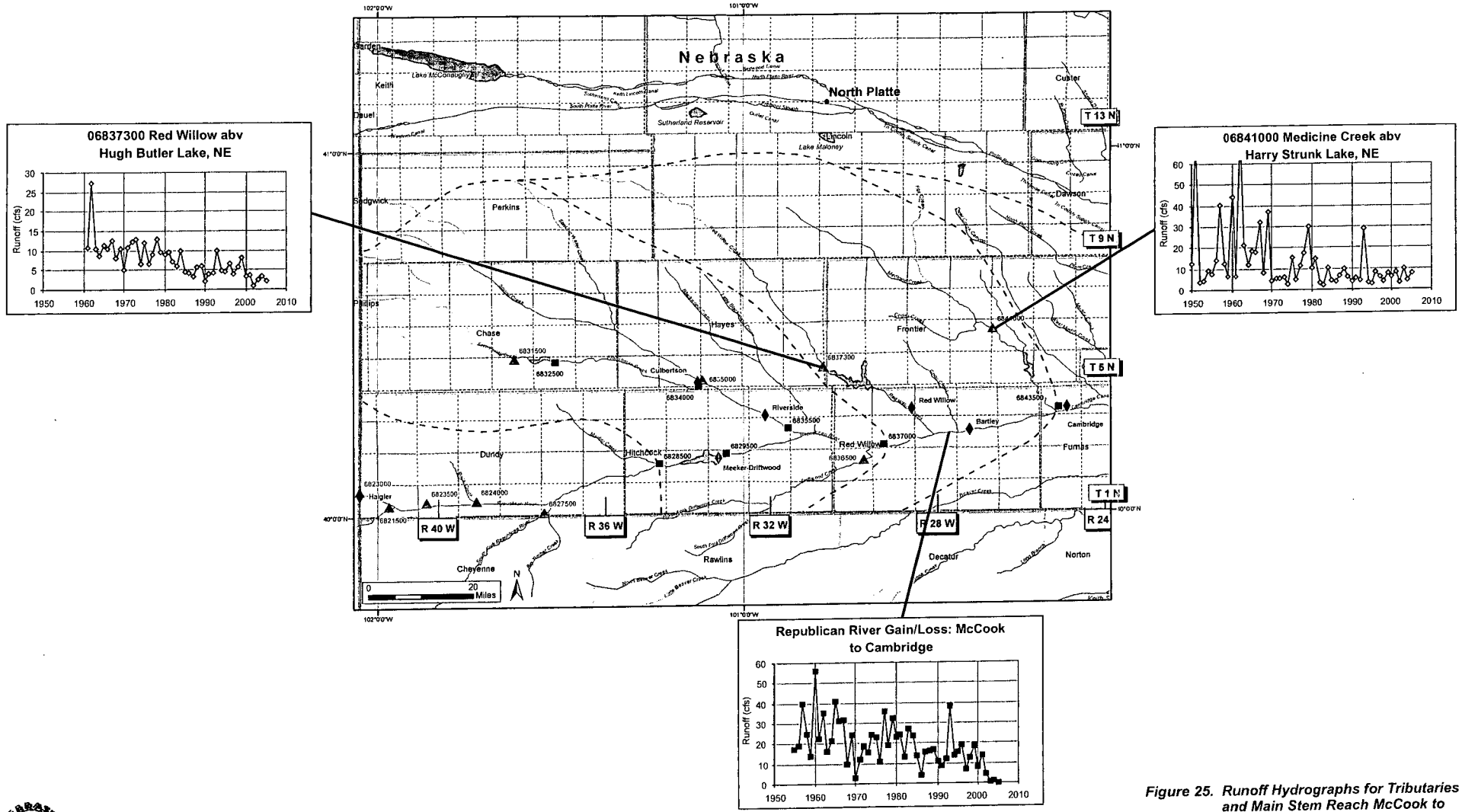


Figure 25. Runoff Hydrographs for Tributaries and Main Stem Reach McCook to Cambridge Groundwater

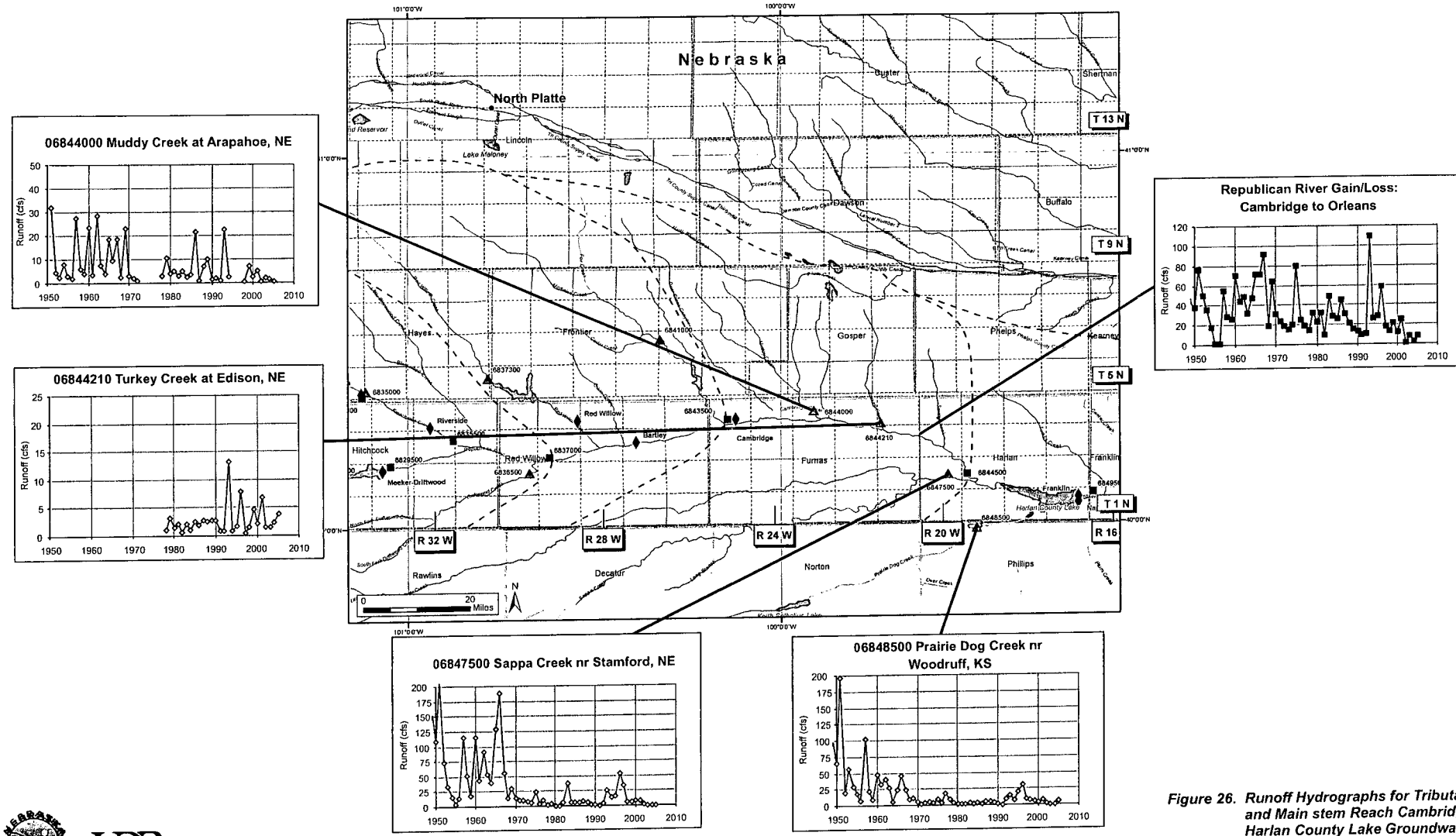


Figure 26. Runoff Hydrographs for Tributaries and Main stem Reach Cambridge to Harlan County Lake Groundwater Flow Zone

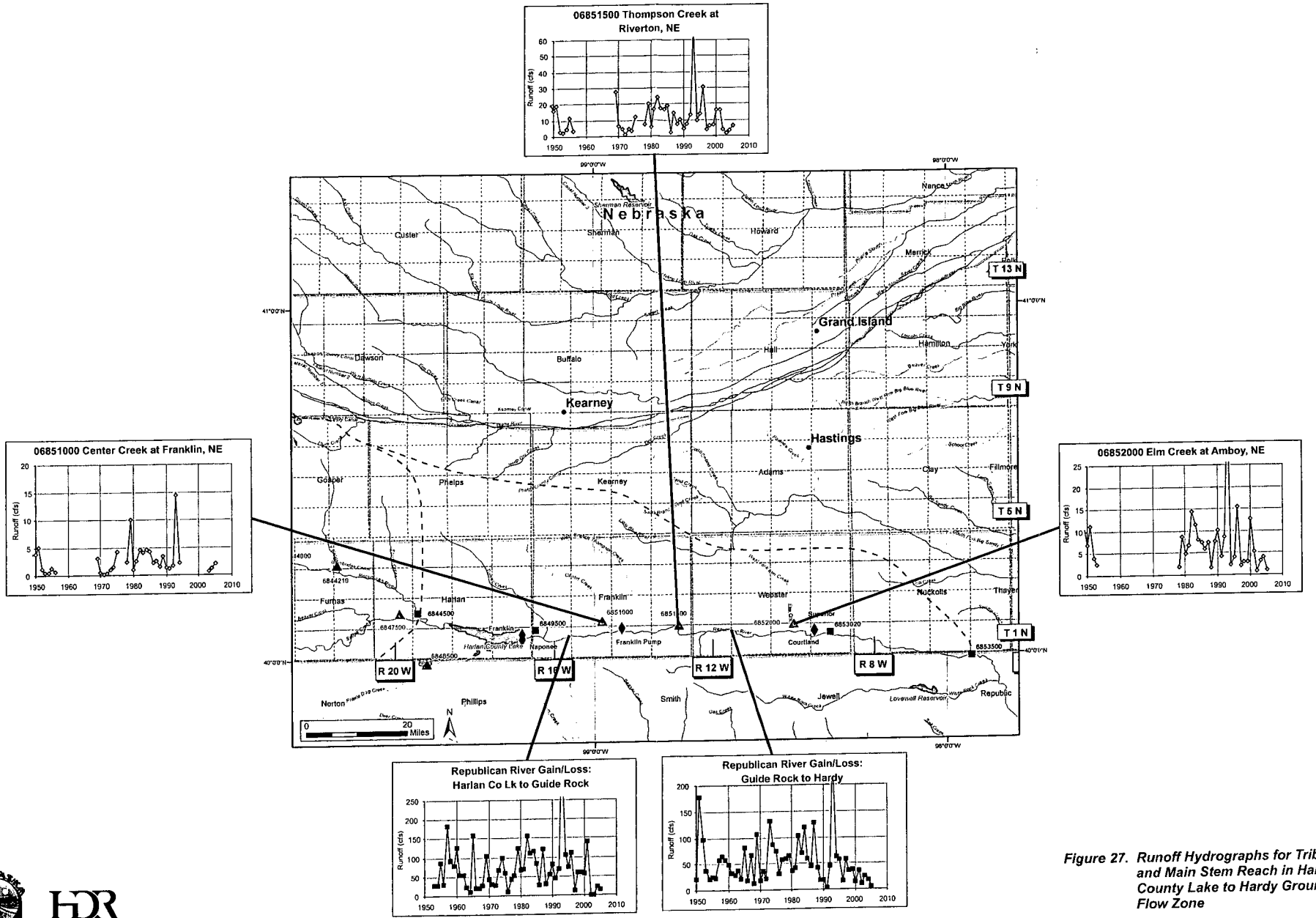


Figure 27. Runoff Hydrographs for Tributaries and Main Stem Reach in Harlan County Lake to Hardy Groundwater Flow Zone

DNR 009001

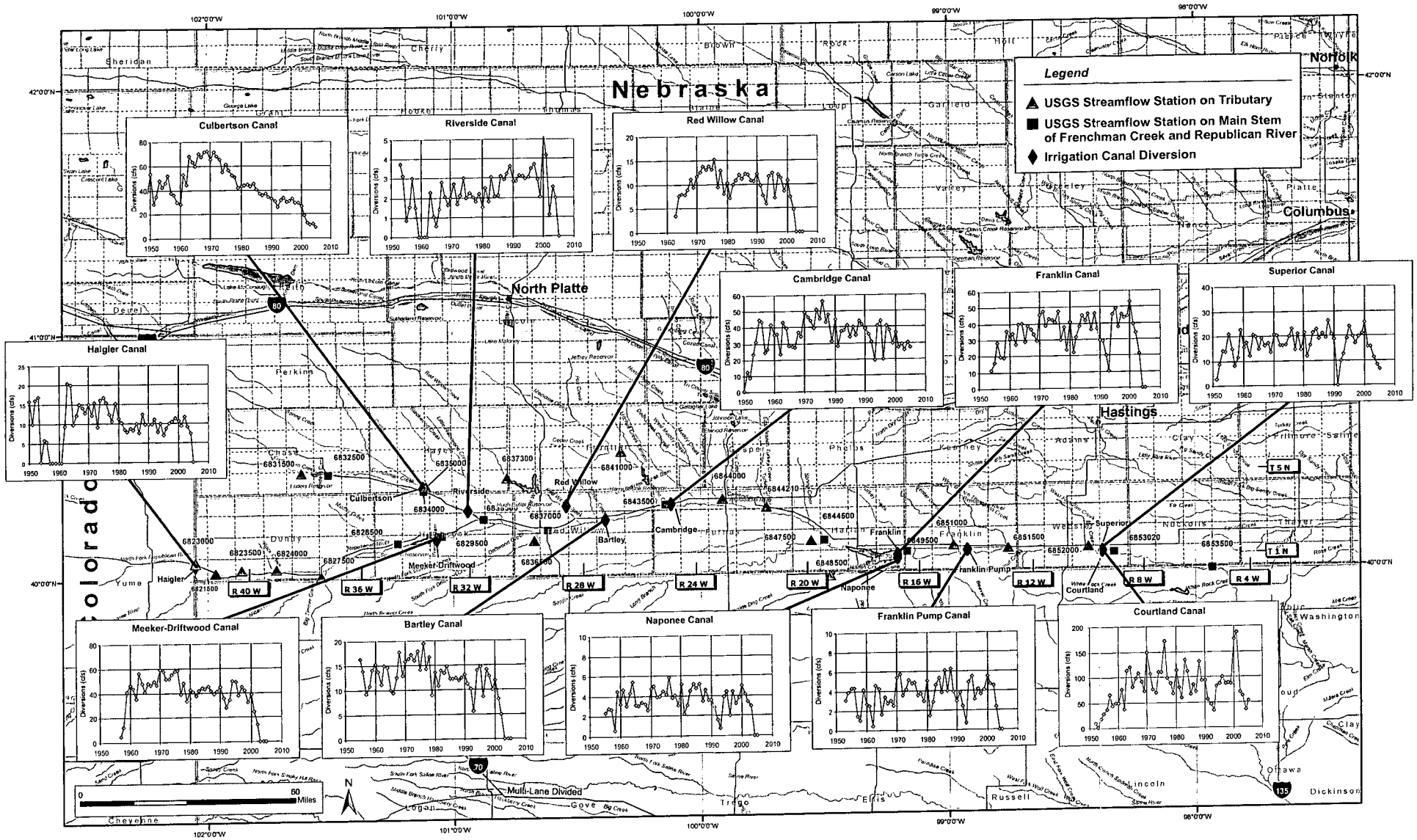
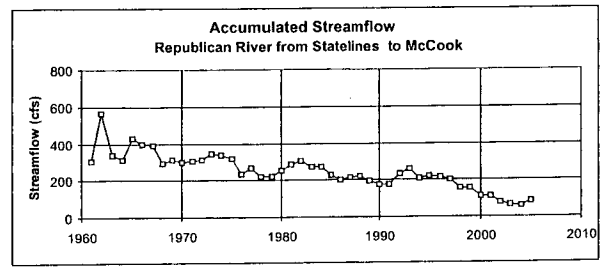
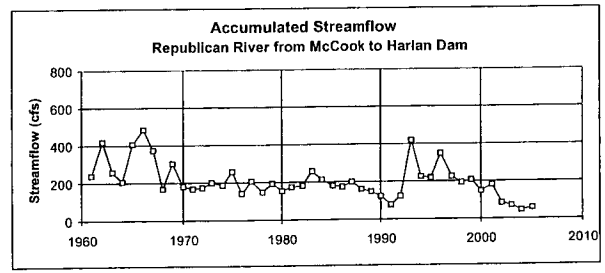
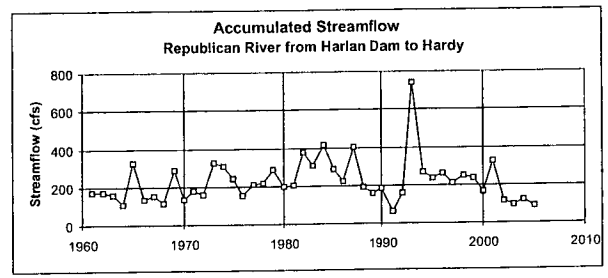


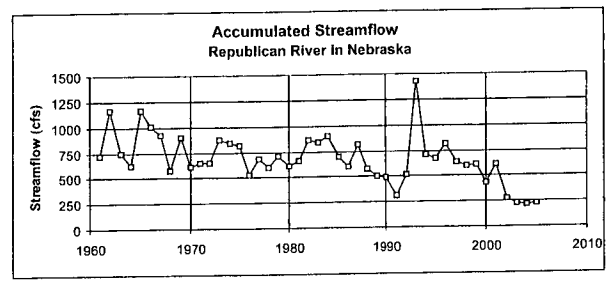
Figure 28. Annual Diversion Hydrographs for Major Canals in Republican River Basin in Nebraska

a. Total Streamflow

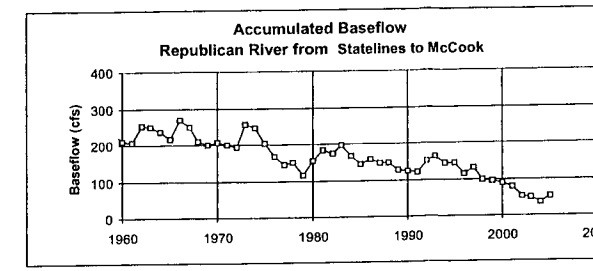


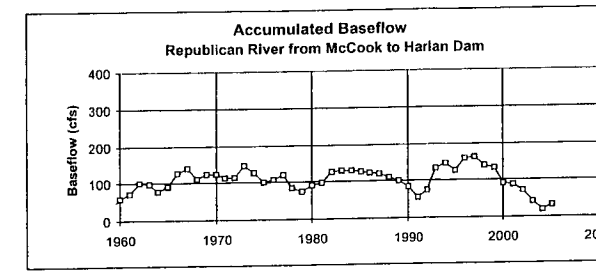


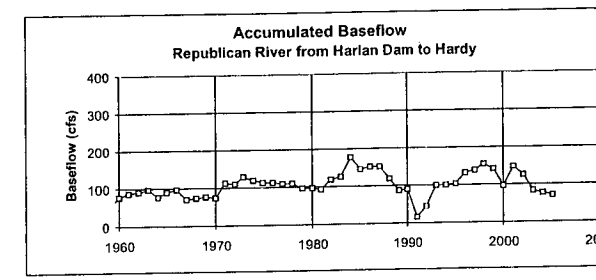




b. Baseflow







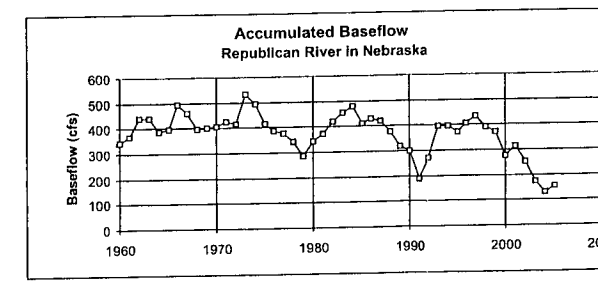


Figure 29. Hydrographs of Cumulative Inflow to the Republican River

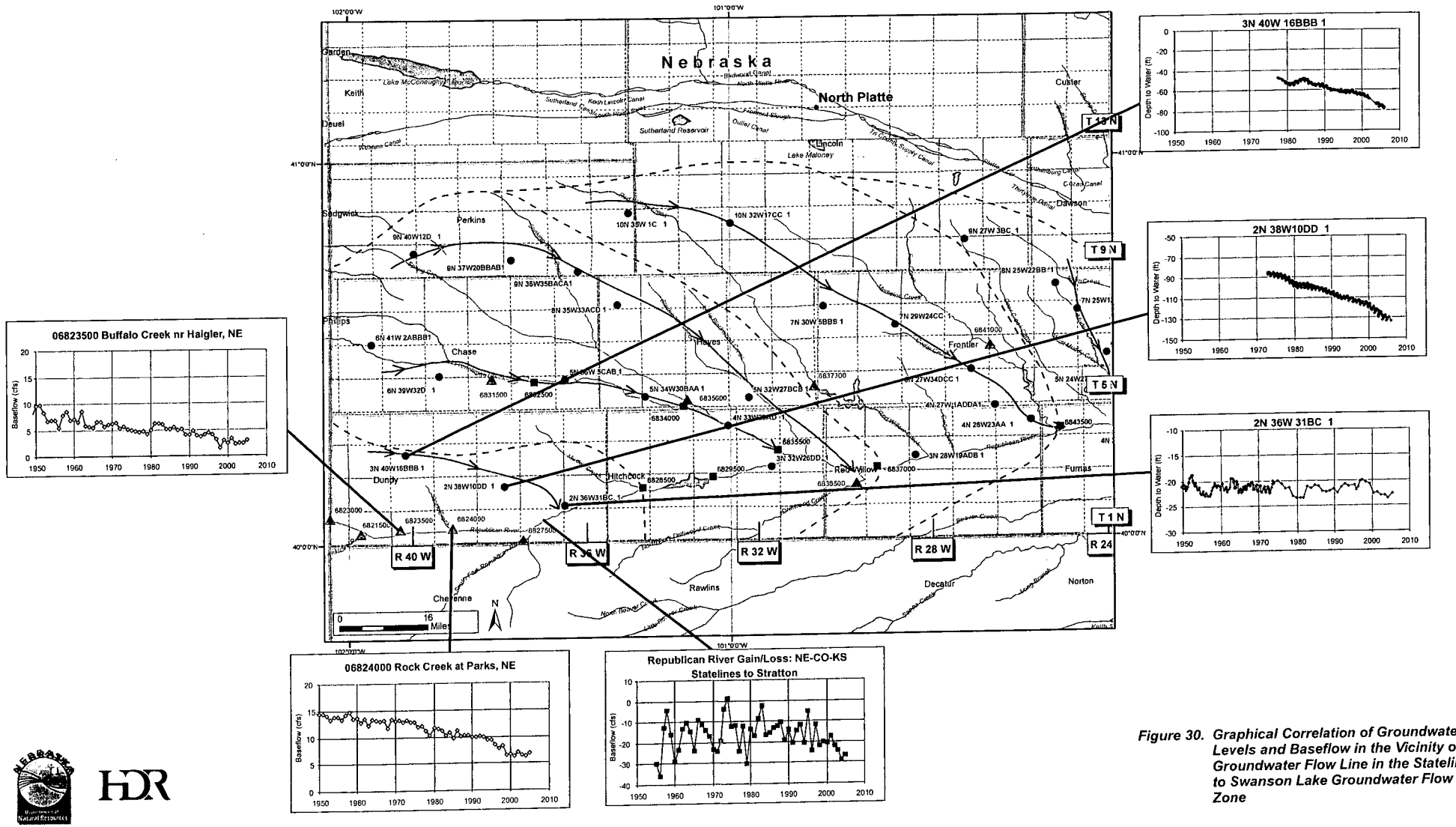


Figure 30. Graphical Correlation of Groundwater Levels and Baseflow in the Vicinity of a Groundwater Flow Line in the Stateline to Swanson Lake Groundwater Flow Zone

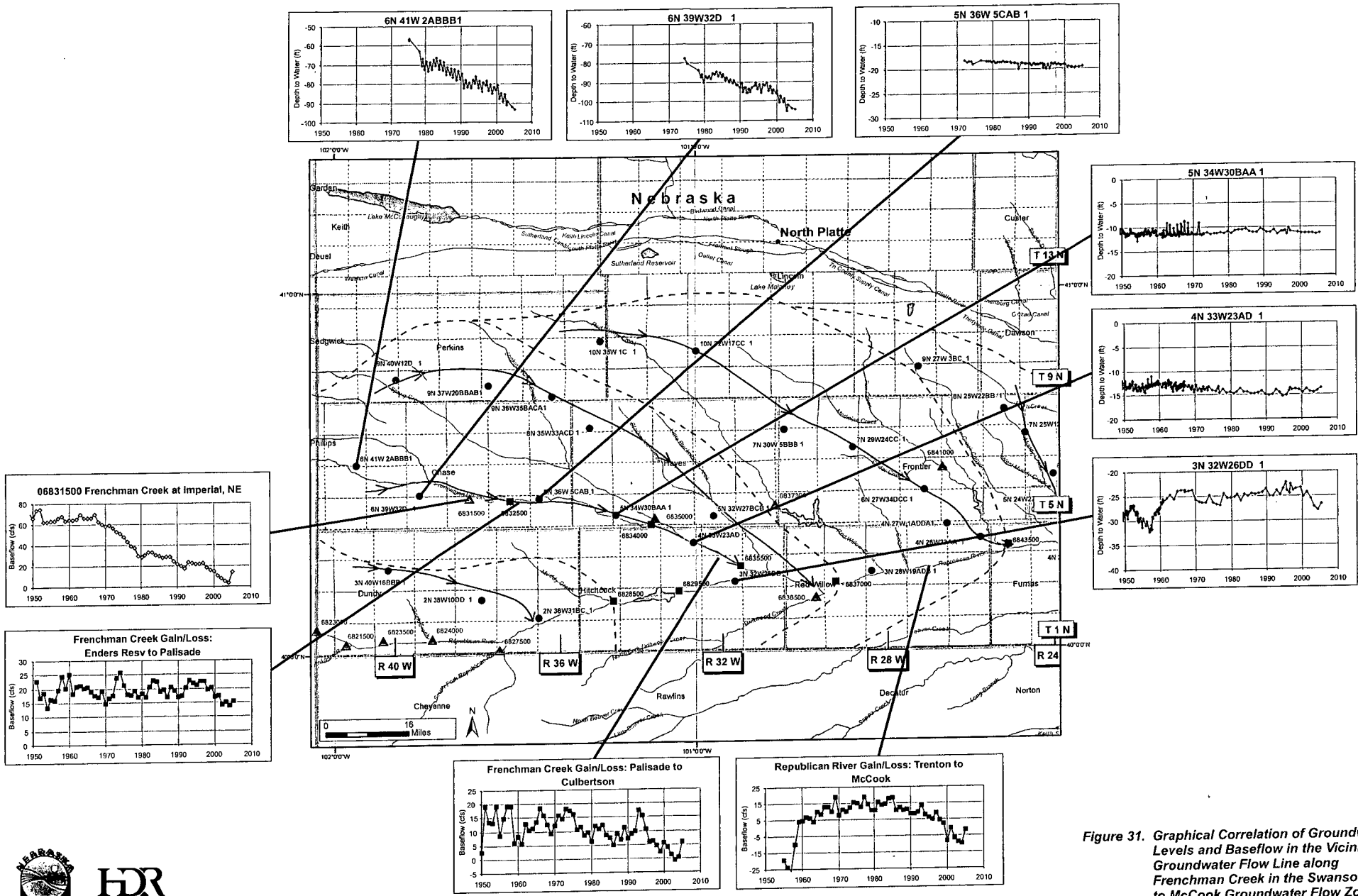


Figure 31. Graphical Correlation of Groundwater Levels and Baseflow in the Vicinity of a Groundwater Flow Line along Frenchman Creek in the Swanson Lake to McCook Groundwater Flow Zone

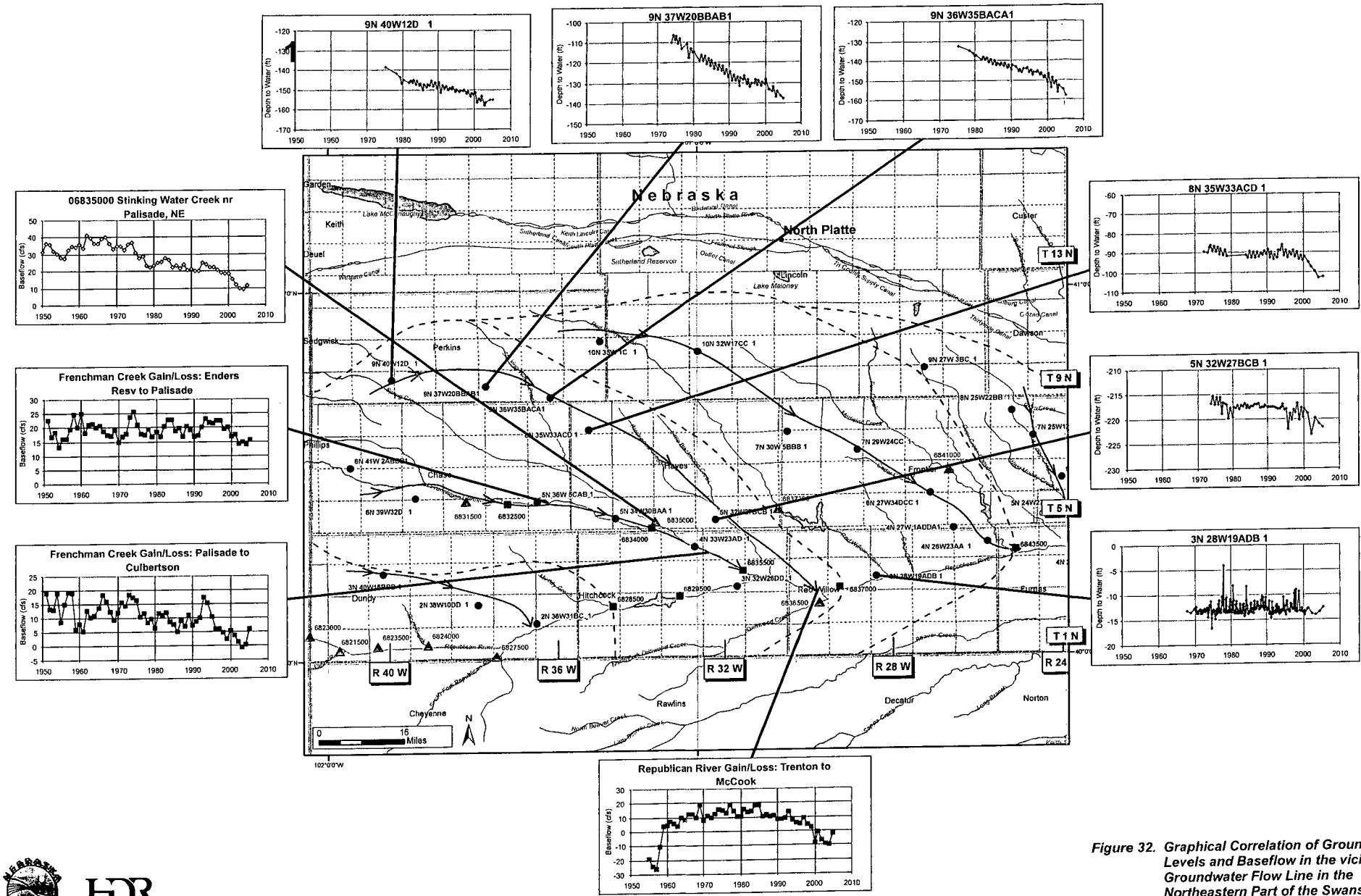


Figure 32. Graphical Correlation of Groundwater Levels and Baseflow in the vicinity of a Groundwater Flow Line in the Northeastern Part of the Swanson Lake to McCook Groundwater Flow Zone

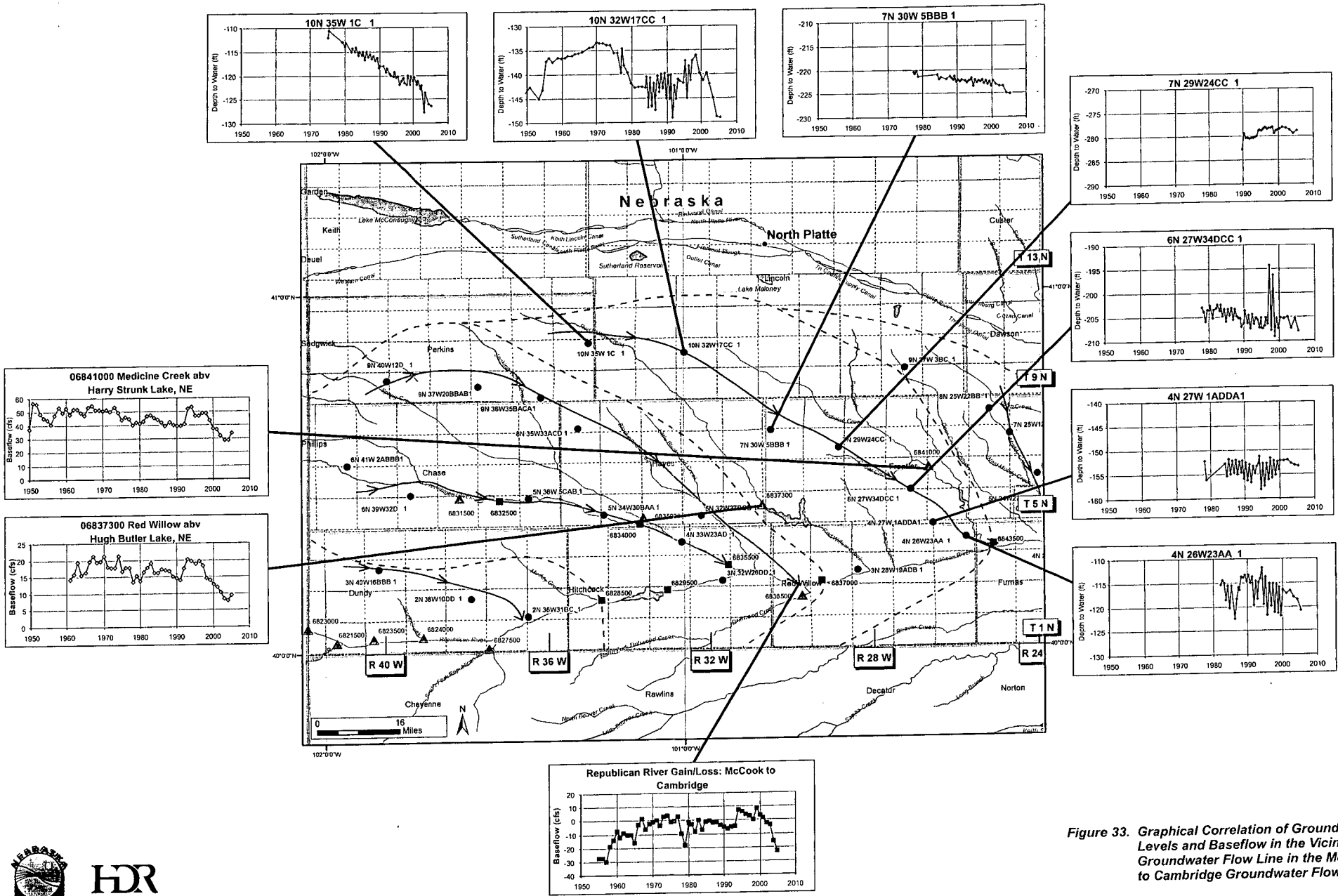


Figure 33. Graphical Correlation of Groundwater Levels and Baseflow in the Vicinity of a Groundwater Flow Line in the McCook to Cambridge Groundwater Flow Zone

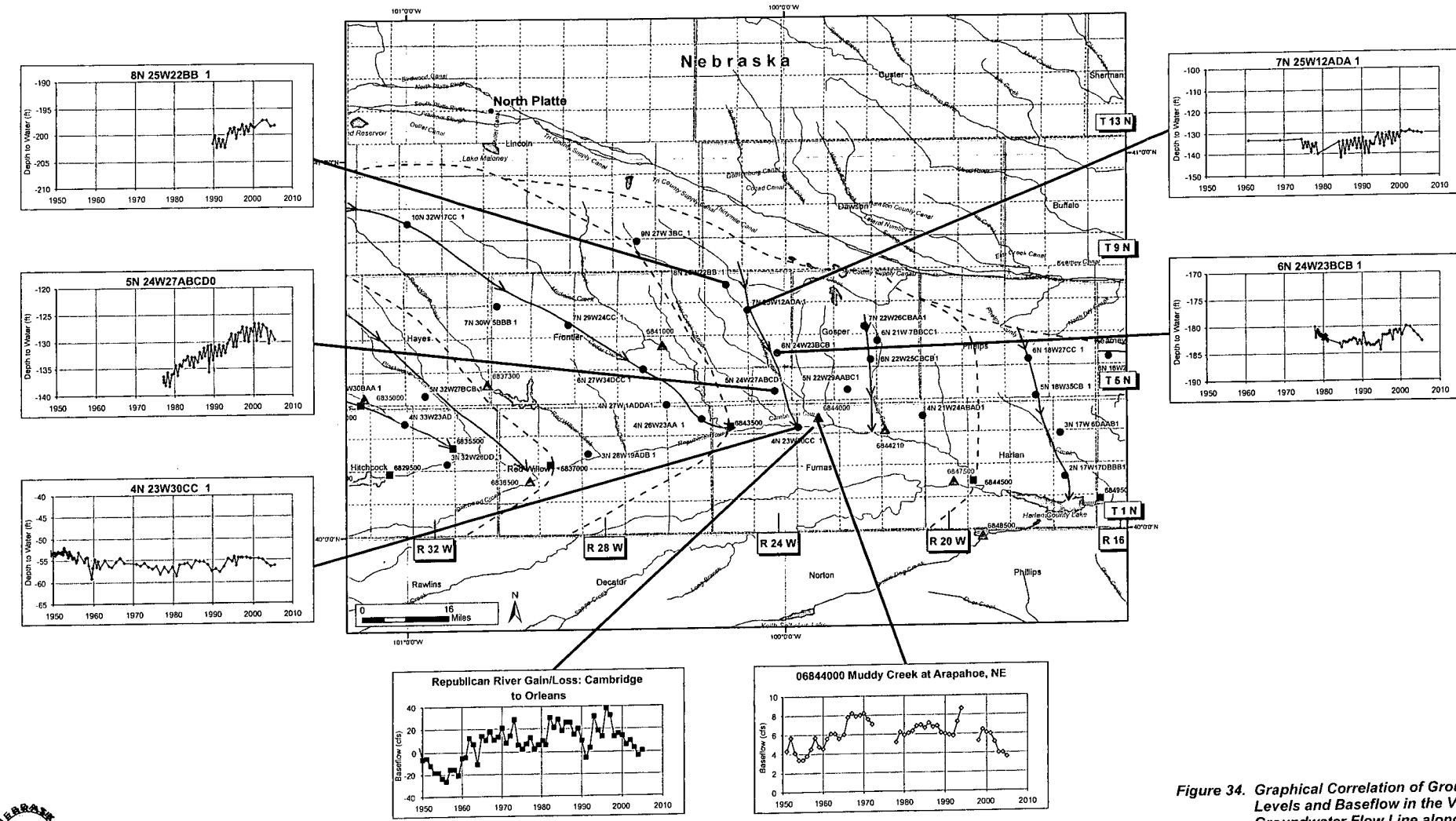


Figure 34. Graphical Correlation of Groundwater Levels and Baseflow in the Vicinity of a Groundwater Flow Line along Muddy Creek in the Cambridge to Harlan County Lake Groundwater Flow Zone

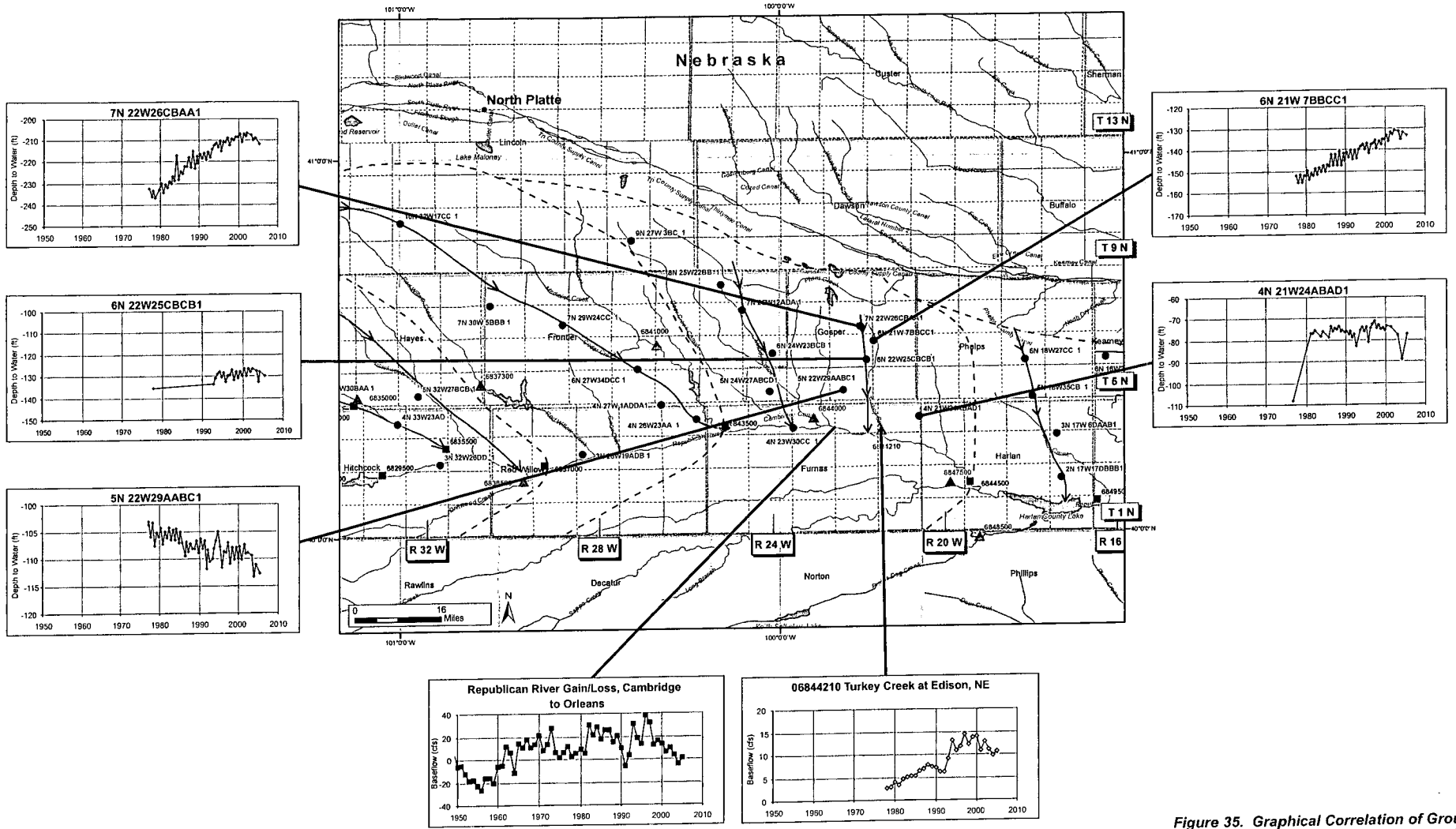


Figure 35. Graphical Correlation of Groundwater Levels and Baseflow in the Vicinity of a Groundwater Flow Line along Turkey Creek in the Cambridge to Harlan County Lake Groundwater Flow Zone

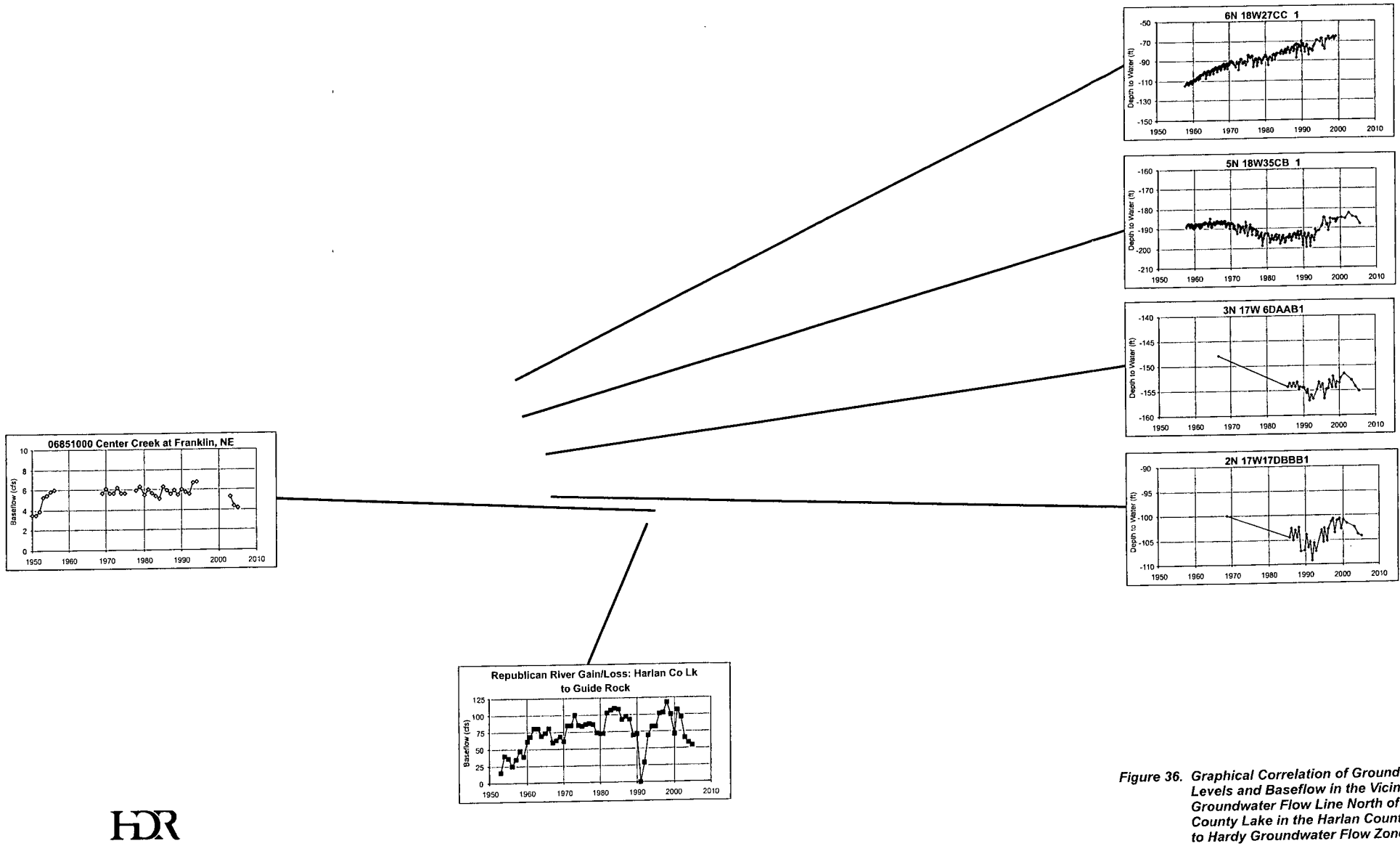


Figure 36. Graphical Correlation of Groundwater Levels and Baseflow in the Vicinity of a Groundwater Flow Line North of Harlan County Lake in the Harlan County Lake to Hardy Groundwater Flow Zone

HDR

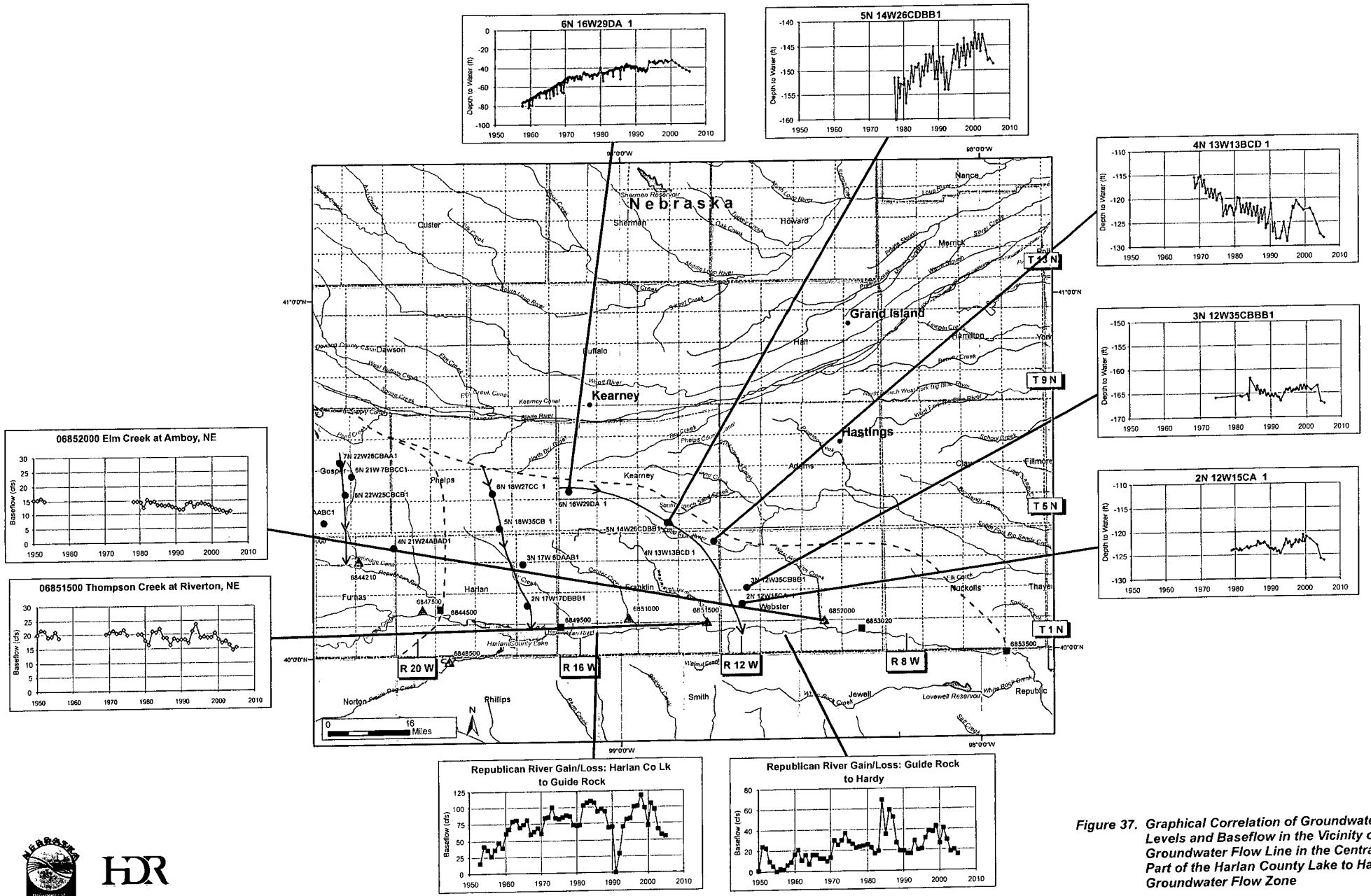


Figure 37. Graphical Correlation of Groundwater Levels and Baseflow in the Vicinity of a Groundwater Flow Line in the Central Part of the Harlan County Lake to Hardy Groundwater Flow Zone