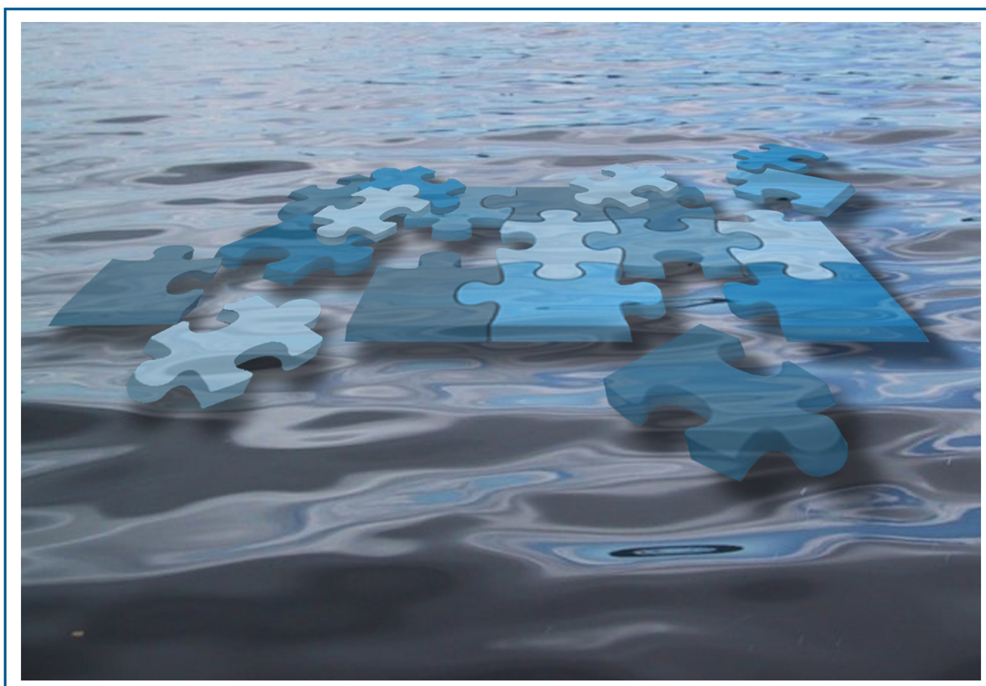
2014

Annual Evaluation of Availability of Hydrologically Connected Water Supplies

Determination of Fully Appropriated



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Report Organization

This report is divided into nine sections. Section One is the report summary. Section Two is the introduction to the report and contains the purpose, background, and organization. The pertinent statutory and regulatory language can be found in Section Three and in Appendix A. Detailed descriptions of the methodologies used in the analyses can be found in Section Four. Sections Five through Eight are the evaluations of the Big Blue River Basins, Lower Niobrara River Basin, Lower Platte River Basin, and Missouri Tributary Basins respectively. Each basin evaluation includes a description of the nature and extent of present water uses, the geographic area considered to have hydrologically connected groundwater and surface water (i.e., the "10/50 area"), preliminary conclusions about the adequacy of the long-term water supply, and whether the preliminary conclusions would change if no additional constraints were placed on water development in the basin. Section Nine is a summary of the basin sub-sections and the report conclusions. The appendices contain additional detailed information not found within the main body of the report.

1.0 SUMMARY

The Nebraska Department of Natural Resources (Department) has evaluated the expected long-term availability of surface water supplies and hydrologically connected groundwater supplies of the Blue River Basins, the Lower Niobrara River Basin, the Lower Platte River Basin, and the Missouri Tributaries Basins, and has concluded that none of the basins or any of the subbasins or reaches within the basins are fully appropriated at the present time. The Department did not evaluate the Niobrara River Basin upstream of the Spencer Hydropower facility in this year's evaluation pursuant to *Neb. Rev. Stat.* § 46-713(1)(a). However, the area upstream of the Spencer Hydropower facility is not fully appropriated at this time.

The Department conducted an additional evaluation of the long-term water supplies with no additional constraints on groundwater and surface water development in the Blue River Basins, the Lower Niobrara River Basin, the Lower Platte River Basin, and the Missouri Tributaries Basins using the best available science and methods. The results of this evaluation indicated that the preliminary determination would not change based on reasonable projections of the extent and location of future development in the basins.

2.0 INTRODUCTION

2.1 Purpose

The purpose of this report is to fulfill the requirements of section 46-713 of the Ground Water Management and Protection Act (Act) (*Neb. Rev. Stat*. §§ 46-701 through 46-753). The Act requires the Department to report annually its evaluation of the expected long-term availability of hydrologically connected water supplies. This annual evaluation is required for every river basin, subbasin, or reach that has not previously been determined to be fully or overappropriated or for which a status change has not occurred within the previous four-year period pursuant to Neb. Rev. Stat § 46-713(1)(a). No re-evaluations were made in this report for basins, subbasins, or reaches that have previously been determined to be fully or overappropriated.

The evaluation and preliminary conclusions of this report are grouped into four river basins: the Blue River Basins, Lower Niobrara River Basin, Lower Platte River Basin, and Missouri Tributary Basins. This format is intended to reduce repetition; however, each appropriate basin, subbasin, and reach was analyzed separately.

As required by statute, the report describes the nature and extent of present water uses in the basins, shows the geographic areas considered to have hydrologically connected surface water and groundwater supplies, and predicts how the Department's preliminary conclusions might change if no new legal restrictions are placed on water development in the basins. The report does not address the sufficiency of groundwater supplies that are not hydrologically connected to surface water streams. The report includes a description of the criteria and methodologies used to determine whether basins, subbasins, or reaches are preliminarily considered to be fully appropriated and which water supplies are hydrologically connected. The report is required to include a summary of relevant data provided by any interested party concerning the social, economic, and environmental impacts of additional hydrologically connected surface water and groundwater uses on resources that are dependent on streamflow or groundwater levels but that are not protected by appropriations or regulations. Appendix B contains the notice of request for any relevant data from any interested party and all comments received.

The Department did not evaluate the Niobrara River Basin upstream of the Spencer Hydropower facility in this year's evaluation pursuant to_*Neb. Rev. Stat*. §§ 46-713(1)(a) and 46-714(12)(a). This portion of the Niobrara River Basin is not fully appropriated at this time. The natural resources districts (NRD) within these basins have developed rules limiting new irrigated acres within their respective districts and the Department will limit the permitting of new appropriations for surface water irrigation within these basins
(*Neb. Rev. Stat*. §§ 46-714 (12)).

2.2 Background

This report addresses requirements that were added to the Act by passage of LB 962 in 2004. That bill was influenced by actions taken as a result of prior legislative activity. In 2002, the Nebraska Unicameral passed LB 1003, mandating the creation of a Water Policy Task Force to address conjunctive use management issues, inequities between surface water and groundwater users, and water transfers/water banking. The 49 Task Force members, appointed by Governor Mike Johanns from a statutorily specified mix of organizations and interests, were asked to discuss issues, identify options for resolution of issues, and make recommendations to the legislature and governor relating to any water policy changes deemed desirable.

In December 2003, the Task Force provided the Legislature with the *Report of the Nebraska Water Policy Task Force to the 2003 Nebraska Legislature*. That report provided draft legislation and suggested changes to statutes. The Legislature considered the Task Force recommendations in its 2004 session and subsequently passed LB 962, which incorporated most of the Task Force's recommendations. Governor Johanns signed the bill into law on April 15, 2004.

The provisions of LB 962 require a proactive approach in anticipating and preventing conflicts between surface water and groundwater users. Where conflicts already exist, it established principles and timelines for resolving those conflicts. It also added more flexibility to statutes governing transfer of surface water rights to a different location of use and updated a number of individual water management statutes.

Some of the key provisions of LB 962 that are part of current statutes include the following:

- The Department must make an annual determination by January 1, 2006, and by January 1 of each subsequent year, as to which basins, subbasins, or reaches not previously designated as fully appropriated or overappropriated have since become fully appropriated. The Department must specify, by rule and regulation, the types of scientific criteria and other information to be utilized in the analysis, complete an annual evaluation of the expected long-term availability of hydrologically connected water supplies in the basins, subbasins, or reaches, and issue a report describing the results of the evaluation.

- When a basin, subbasin, or reach is determined to be fully appropriated, stays on new uses of groundwater and surface water are automatically imposed. The Department and the NRDs involved are required to develop and implement jointly an integrated management plan (IMP) within three to five years of that designation.

- A key goal of each IMP must be to manage all hydrologically connected groundwater and surface water for the purpose of sustaining a balance between water uses and water supplies so that the economic viability, social and environmental health, safety, and welfare of the basin, subbasin, or reach can be achieved and maintained for both the near- and long-term. In the overappropriated portions of the state, the IMP must provide for a planned incremental approach toward achieving a balance between water uses and water supplies.

- IMPs may rely on a number of voluntary and regulatory controls, including incentives, allocation of groundwater withdrawals, rotation of use, and reduction of irrigated acres, among others.

- If disputes between the Department and the NRDs over the development or implementation of an IMP cannot be resolved, the governor will appoint a five-member Interrelated Water Review Board to resolve the issue.

Shortly after the passage of LB 962, a number of basins, subbasins, or reaches were determined to be fully or overappropriated. These areas included portions of the Platte River Basin, Republican River Basin, Upper Niobrara River Basin, White River Basin, and Hat Creek Basin (Figures 2-1 and 2-2). Additionally, following the status change of the Lower Platte River Basin preliminary determination in April 2009, the legislature passed LB 483 and LB 54.

Some of the key provisions of LB 483 and LB 54 that are relevant to development of this report include the following:

- The NRDs affected by a status change (reversal of preliminary determination that a basin, subbasin, or reach is fully appropriated) of a basin, subbasin, or reach must develop rules to limit the total number of new groundwater irrigated acres annually for a period of at least four years following the status change.

- The Department must approve the NRDs' proposed number of new irrigated acres if the basin, subbasin, or reach would not be caused to be fully appropriated based on the most recent annual evaluation. Absent such approval, the NRDs must limit new irrigated acres to 2,500 or 20 percent of the historically irrigated acres, whichever is less.

- The Department must ensure that any new appropriation granted will not cause the basin, subbasin, or reach to be fully appropriated based on the most recent annual evaluation.

- The Department must limit new natural flow surface water appropriations for irrigation within the basin, subbasin, or reach to ensure that there is not a net increase of more than 834 irrigated acres in each NRD during each calendar year of the four-year period.

- The Department is not required to perform an annual evaluation for a river basin, subbasin, or reach during the four years following a status change in such river basin, subbasin, or reach.

Areas that are currently subject to the restrictions resulting from the passage of LB 483 are illustrated in Figures 2-3 and 2-4.

Previous statutorily required reports on the evaluation of hydrologically connected water supplies are available online (http://dnr.ne.gov/IWM/docs/IWM_AnnualReports.html), or upon request from the Department.

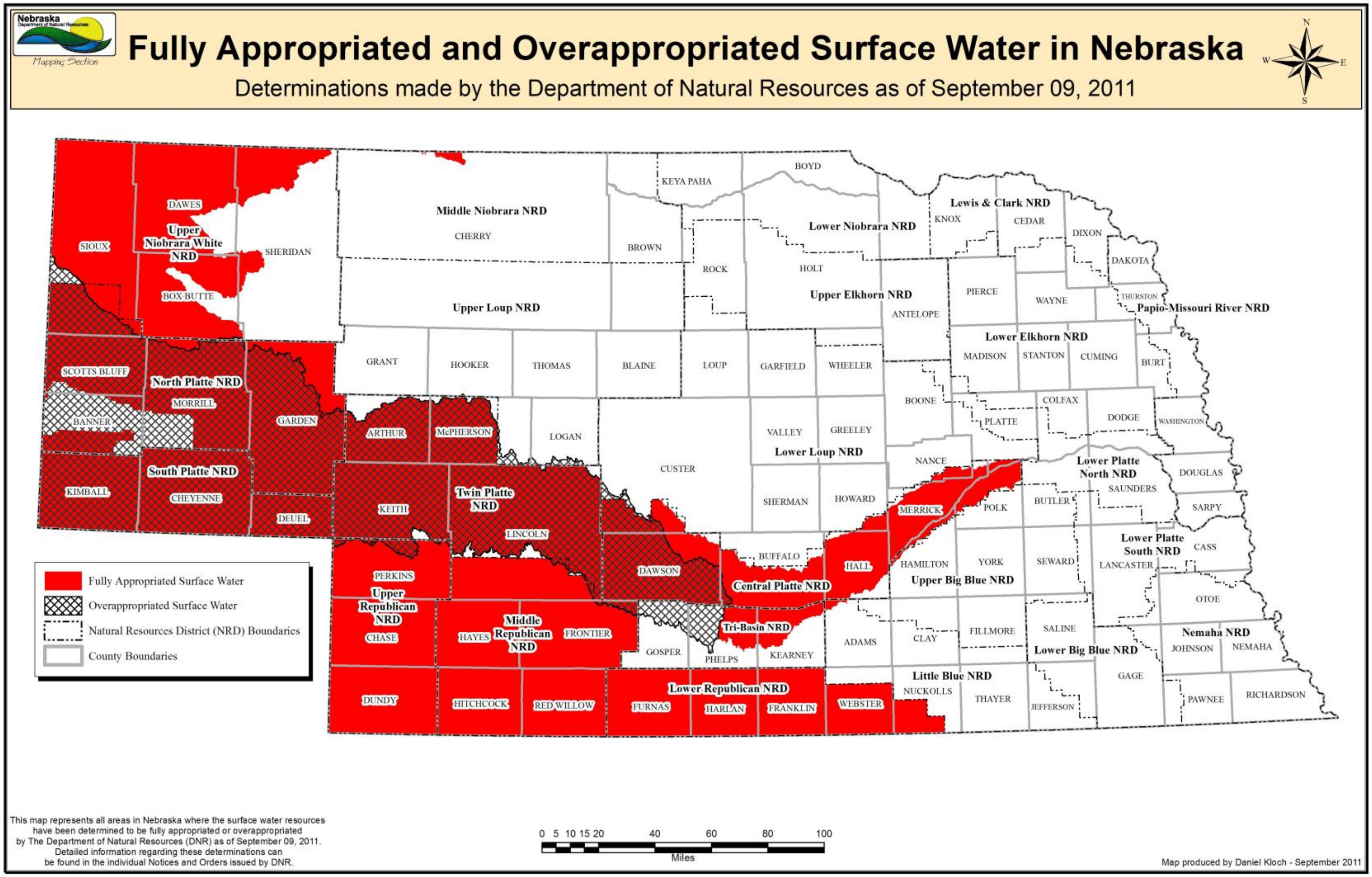


Figure 2-1. Areas designated as fully appropriated or overappropriated basins, subbasins, and reaches since the passage of LB 962.

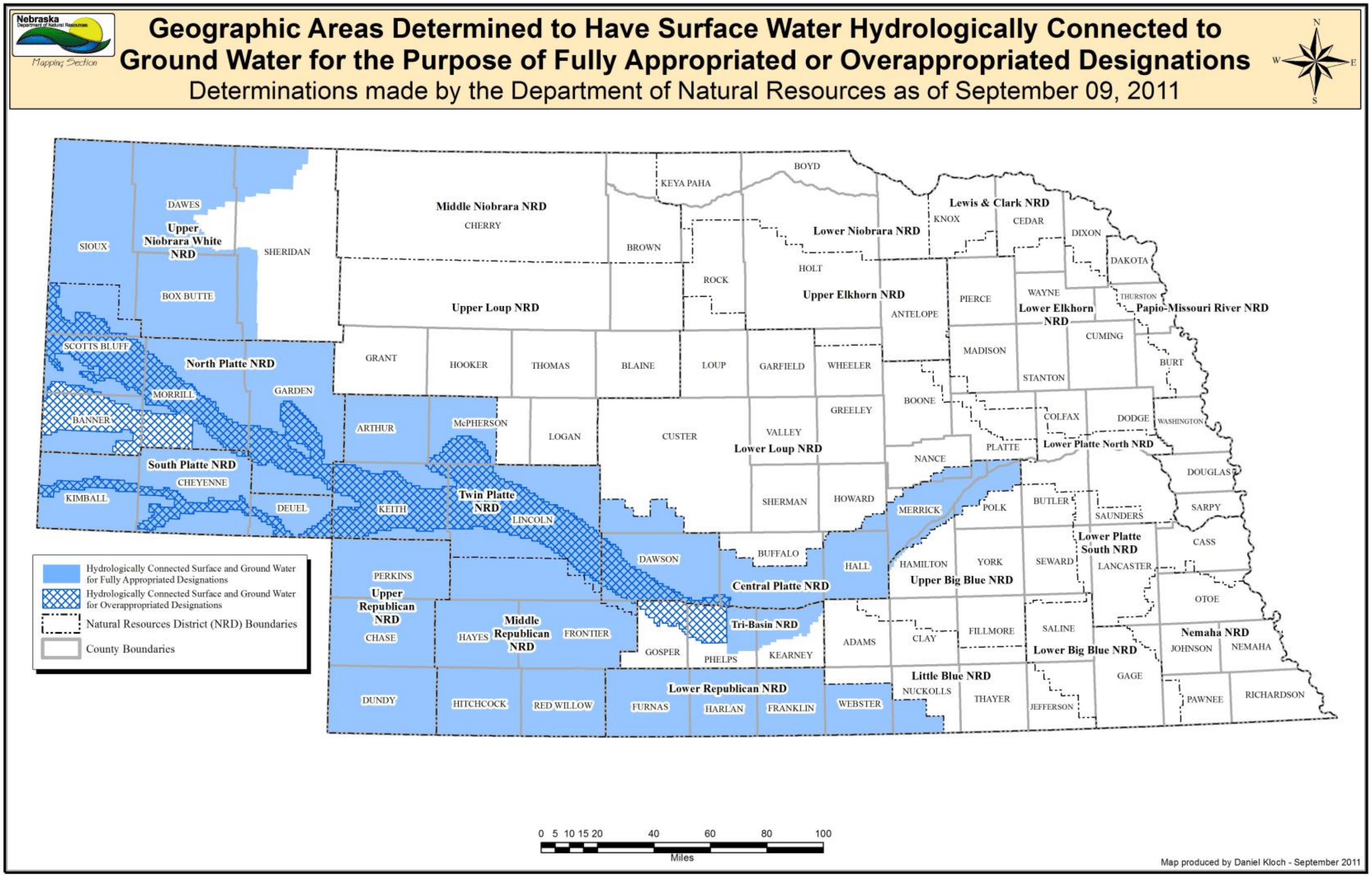


Figure 2-2. Areas designated as hydrologically connected to fully appropriated or overappropriated basins, subbasins, and reaches since the passage of LB 962.

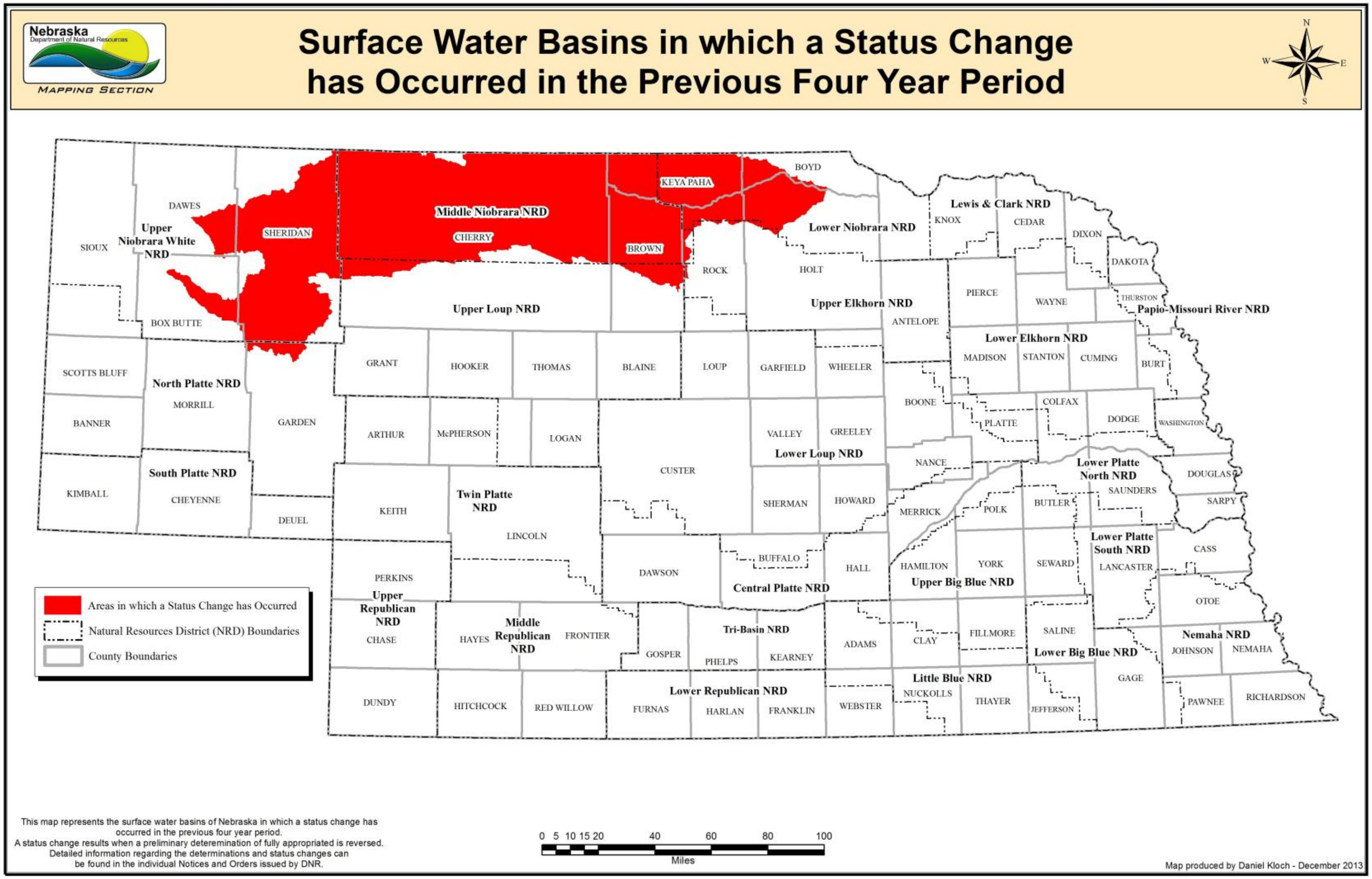


Figure 2-3. Surface water basins in which a status change has occurred in the previous four-year period.

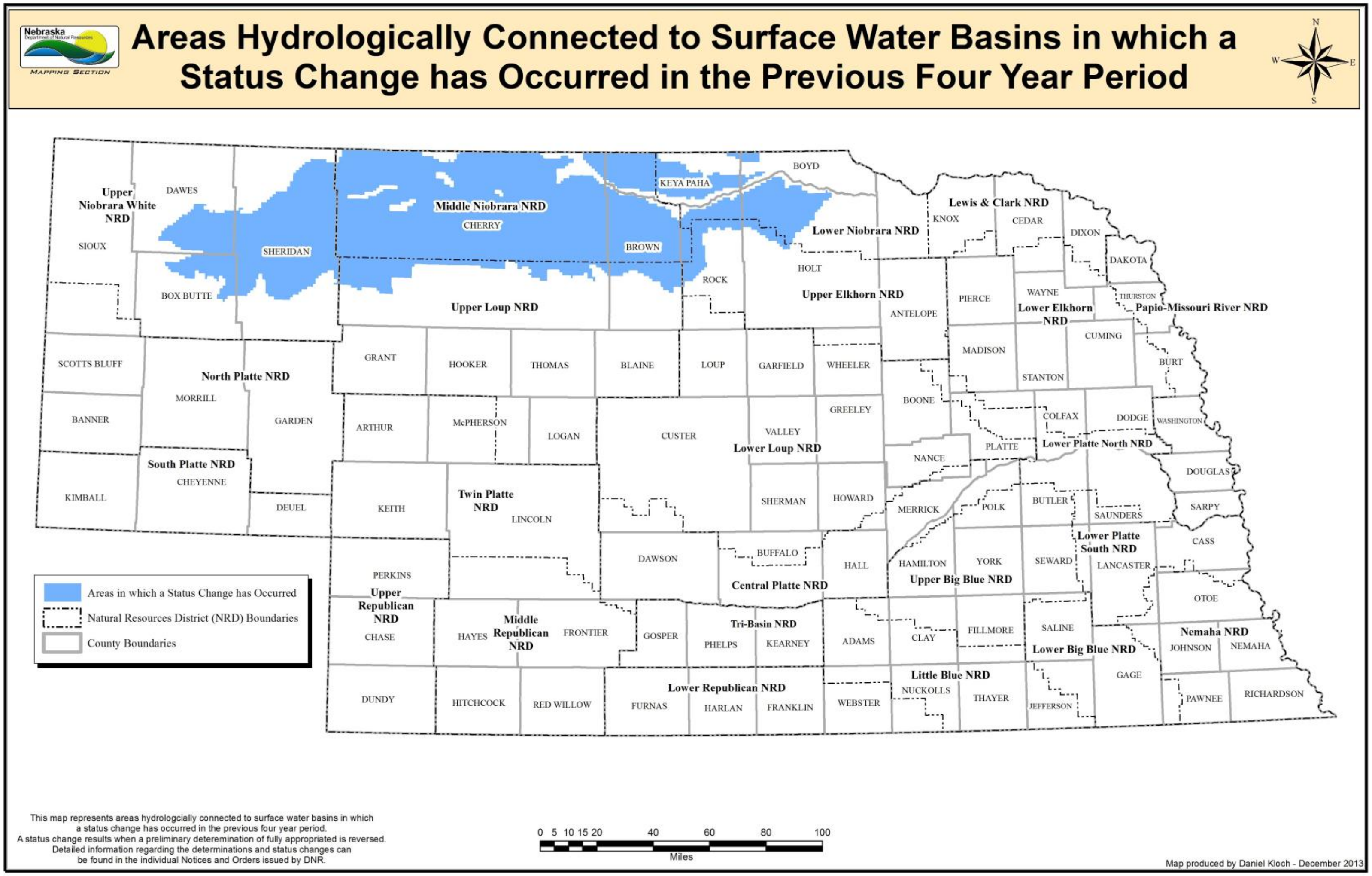


Figure 2-4. Areas hydrologically connected to surface water basins in which a status change has occurred in the previous four-year period.

3.0 LEGAL REQUIREMENTS

3.1 Section 46-713(1)(a) – Annual Evaluation and Report Required

A river basin's hydrologically connected water supplies include the surface water in the watershed or catchment that runs off to the stream and the groundwater that is in hydrologic connection with the stream. For all evaluated basins, the geographic areas of hydrologically connected surface water and groundwater, where present, are illustrated on a basin-wide map that is included in each basin sub-section of the report. On each of those maps, the surface watershed basin is shown by a solid line, and the hydrologically connected groundwater portion of the basin is depicted by a shaded area.

Surface water supplies are considered to be hydrologically connected to a stream or stream reach if the surface water drains to that stream or reach. In accordance with Department rule 457 NAC 24.001.02, the Department considers the area within which groundwater is hydrologically connected to a stream to be that area in which "pumping of a well for 50 years will deplete a river or baseflow tributary thereof by at least 10 percent of the amount pumped in that time" (i.e., the "10/50 area"). For the purposes of evaluation, a river basin may be divided into two or more subbasins or reaches. Basins that have not previously been determined as overappropriated or fully appropriated or that have not experienced a status change (reversal of preliminary determination that a basin, subbasin, or reach is fully appropriated) in the previous four years are required to be evaluated.

In preparing its annual report, the Department is required by *Neb. Rev. Stat.* § 46-713(1)(d) to rely on the best scientific data, information, and methodologies readily available to ensure that the conclusions and results contained in the report are reliable. A list of the information the Department may use is found in rule 457 NAC 24.002 (Appendix A). The Department is also required to provide enough documentation in the report to allow others to replicate and assess the Department's data, information, methodologies, and conclusions independently. That documentation can be found throughout the report. The raw data used for these calculations and the spreadsheets with the calculations will be provided by the Department upon request.

3.2 Section 46-713(1)(b) – Preliminary Conclusions Following Basin Evaluations

As a result of its annual evaluation, the Department is to arrive at a preliminary conclusion as to whether or not each river basin, subbasin, and reach evaluated is currently fully appropriated without the initiation of additional uses. The Department is also required to determine if and how its preliminary conclusions would change if no additional legal constraints were imposed on future development of hydrologically connected surface water and groundwater. This determination is based on reasonable projections of the extent and location of future development in a basin.

3.3 Section 46-713(3) – Determination that a Basin is Fully Appropriated

The Department must make a final determination that a basin, subbasin, or reach is fully appropriated if the current uses of hydrologically connected surface and groundwater in the basin, subbasin, or reach cause, or will in the reasonably foreseeable future cause, either (a) the surface water supply to be insufficient to sustain over the long-term the beneficial or useful purposes for which existing natural flow or storage appropriations were granted, (b) the streamflow to be insufficient to sustain over the long-term the beneficial uses from wells constructed in aquifers dependent on recharge from the river or stream involved, or (c) reduction in the flow of a river or stream sufficient to cause noncompliance by Nebraska with an interstate compact or decree, other formal state contract, or agreement, or applicable state or federal laws. Since these factors must be considered in making the final determination, they must also be part of the Department's considerations in reaching its preliminary conclusions.

The Department considered whether or not condition (c) would be met with regard to interstate compacts by reviewing the terms of any compacts in each basin and determining when noncompliance would occur if there were sufficient reductions in streamflow. There were no decrees, formal state contracts, or agreements in any of the basins evaluated this year; there is one interstate compact covering the Blue River Basins.

With regard to noncompliance with state and federal law, it was determined that only the state and federal laws prohibiting the taking of threatened and endangered species could raise compliance issues that would trigger condition (c). The federal Endangered Species Act (ESA), 16 U.S.C. §§ 1530 *et seq.*, prohibits the taking of any federally listed threatened or endangered species of animal by the actual killing or harming of an individual member of the species (16 U.S.C. § 1532) or by the significant modification or degradation of designated critical habitat where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR § 17.3). The state Nongame and Endangered Species Conservation Act (NNESCA), *Neb. Rev. Stat*. §§ 37-801 *et seq.*, also prohibits the actual killing or harming of an individual member of a listed species, and the destruction or modification of designated critical habitat. It was concluded that any reductions in flow that may occur as a result of not determining a basin, subbasin, or reach to be fully appropriated will not cause noncompliance with either federal or state law at this time in any of the basins evaluated.

Prior to making a final determination that a basin is fully appropriated, the Department must also hold a public hearing on its preliminary conclusions and consider any testimony and information given at the public hearing or hearings.

4.0 METHODOLOGY

This section provides an overview of the methodologies used in the Department's basin evaluations and is separated into three sub-sections.

1) The first sub-section outlines the legal requirements established in section 46-713 of the Ground Water Management and Protection Act and regulation 457 NAC 24 (Appendix A) as they relate to the analysis.
2) The second sub-section provides the overall procedure for evaluation of each basin.
3) The third sub-section discusses the specific methods implemented by the Department to calculate the extent of the 10/50 area.

4.1 Legal Obligation of the Department

4.1.1 The Legal Requirements of Section 46-713

The methodologies used for evaluation within this report were developed to meet the requirements of section 46-713 of the Act. The criteria set forth in section 46-713 require the Department to: 1) describe the nature and extent of surface and groundwater uses in each river basin, subbasin, or reach; 2) define the geographic area within which surface water and groundwater are hydrologically connected; 3) define the extent to which current uses will affect available near-term and long-term water supplies; and 4) determine how preliminary conclusions based on current development would change if no additional legal constraints were imposed on reasonable projections of future development.

The description of the nature and extent of surface and groundwater uses is based on information obtained through published reports from the University of Nebraska-Conservation and Survey Division (CSD), the U.S. Geological Survey (USGS), NRDs, Department databases, and other sources as noted in the text. The information represents the most current publications available. These data include information on transmissivity, specific yield, saturated thickness, depth to water, surficial geology, bedrock geology, water table elevation change, and test-hole information. These data are available on the CSD and USGS websites, http://snr.unl.edu/csd/ and http://waterdata.usgs.gov/ne/nwis/nwis, respectively. All data utilized in this report are available at: ftp://dnrftp.dnr.ne.gov/Pub/FAB_Report/FAB_Report_2014/ or from the Department upon request.

These data and the following methodologies are provided to allow for complete reproducibility of the results.

4.1.2 Regulation 457 NAC 24.001

The Department's evaluation of the extent to which current uses will affect available near-term and long-term water supplies considers current surface water appropriations, current well development, and the 25-year lag impacts from that current well development on surface water flows. For the purposes of this report, lag impacts are defined as the delayed effect that the consumptive use of water associated with well pumping will have on hydrologically connected streamflow and its associated impact on surface water appropriations.

Regulation 457 NAC 24.001 generally states that a basin is fully appropriated if current uses of hydrologically connected surface water and groundwater in a basin cause, or will cause in the reasonably foreseeable future; (a) the surface water to be insufficient to sustain over the long-term the beneficial purposes for which the existing surface water appropriations were granted; (b) the streamflow to be insufficient to sustain over the long-term the beneficial uses from wells constructed in aquifers dependent on recharge from the basin's river or stream; or (c) reduction in streamflow sufficient to cause Nebraska to be in noncompliance with an interstate compact or decree, formal state contract, or state or federal laws.

In short, regulation 457 NAC 24.001 states that the surface water supply is deemed to be insufficient if, at current levels of development, the most junior irrigation right in a basin, subbasin, or reach has been unable to divert sufficient surface water over the last 20 years to provide 85 percent of the amount of water a corn crop needs (the net corn crop irrigation requirement, or NCCIR) during the irrigation season (May 1 through September 30), or if the most junior irrigation right in a basin, subbasin, or reach is unable to divert 65 percent of the amount of water a corn crop needs during the key growing period of July 1 through August 31. For the purposes of this report, this is deemed the "65/85 rule."

If the requirements of the 65/85 rule are not satisfied, then the final step in a preliminary conclusion of whether a basin is fully appropriated is to apply what has been termed the "erosion rule" (457 NAC 24.001.01C). This rule takes into account the fact that appropriations may be granted even though sufficient water is not available at the time they are granted to provide enough water for diversion to satisfy the requirements of the 65/85 rule. If an appropriation is unable to divert enough water to satisfy the requirements of the 65/85 rule, a second evaluation is completed to determine if the right has been "eroded." According to regulation 457 NAC 24.001.01B, in the event that the junior water right is not an irrigation right, the Department will utilize a standard of interference appropriate for the type of water use to determine whether flows are sufficient for that use, taking into account the purpose for which the appropriation was granted.

The Department is also required to assess how its preliminary conclusions, based on current development, might change by predicting future development. The predictions of future development account for existing wells and wells that may be added in the next 25 years. When projecting the quantity of wells that may be added to the number of currently developed wells, the Department considers the following: 1) the availability of lands suitable for irrigation; 2) the extent of well-construction moratoriums established by NRDs; and 3) trends in well development over the previous ten-year period.

4.1.2.1 The Role of the Surface Water Administration Doctrine in Implementation of the 65/85 Rule

The administration of surface water plays a key role in evaluating the sustainability of development within a basin, subbasin, or reach. Surface water appropriations in Nebraska are administered under the doctrine of prior appropriation. The basis for the doctrine is "first in time, first in right." When surface water is in short supply in a basin, subbasin, or reach, the surface water appropriation with a senior priority date has the right to use any available water for beneficial use, up to its permitted limit, before any upstream junior surface water appropriation can use water. To exercise a senior right, the senior water appropriation will put a call on the stream; the Department will investigate the streamflows, and, if necessary, issue closing orders to the upstream junior water appropriations, starting with the most junior right.

Although additional surface water development in a basin will deplete the overall surface water supplies during times when excess surface water is available, under the priority system a junior right cannot cause a senior surface water appropriation's supply to be reduced. When the Department administers for a calling senior surface water appropriation, all upstream junior surface water appropriations, starting with the most junior appropriator, are shut off in order of priority, no matter how far upstream, until the calling senior surface water appropriation is satisfied. Therefore, in areas where surface water administration is already occurring, additional surface water development will not reduce the number of days surface water is available for diversion by a senior surface water appropriation. In areas that have not experienced surface water administration, it is not feasible to predict the point at which additional surface water development may cause surface water administration to occur.

The priority doctrine, which governs surface water administration, ensures that if sufficient water is available for the most junior irrigation appropriation, then all irrigation appropriations will be satisfied. Therefore, the Department analyzed the water available to the most junior appropriator in each basin evaluation. When making the calculation of the number of days that surface water was available to the most junior irrigation surface water appropriator, the Department assumed that, if the junior appropriator was not closed, then he or she could have diverted at the full permitted diversion rate.

4.1.3 Regulation 457 NAC 24.001.002

The Department must determine the geographic area within which surface water and groundwater are hydrologically connected. Regulation 457 NAC 24.001.02 states that the geographic area within which the groundwater and surface water are hydrologically connected is determined by calculating where, in each river basin, a well would deplete a river's flow by 10 percent of the amount of water the well could pump over a 50-year period (i.e., "the 10/50 area"). The 10/50 area serves as the minimum area that would be subject to preliminary stays when a basin is determined to be fully appropriated, requirements of an IMP, or to restrictions on the development of irrigated acres following a basin status change.

4.1.4 Utilization of the Best Available Science in the Annual Evaluation

The Department must rely on the best scientific data, information, and methodologies readily available to ensure that the conclusions and results arrived at through the annual evaluation are reliable. The Department has specified by rule and regulation the types of scientific data and other information that will be considered (457 NAC 24.002) in the annual evaluation. Specific data relied upon by the Department is referenced throughout this report and is sited in the section bibliographies.

A key component of the methods used by the Department in this report is the implementation of methods to assess stream depletions by groundwater wells. There are several methods available for estimating the extent and magnitude of stream depletions. Historically, three broad categories have been used to study groundwater flow systems, including sand tank models, analog models, and mathematical models, which include analytical models and numerical models. The first two methods were primarily used prior to the advent of modern, high-speed, digital computers. Since the advent of computers, analytical and numerical models have become the preferred methods for evaluating groundwater flow. Limitations of each method must be considered by the user when examining the results of analyses and the appropriateness of each method for a given task. With user-friendly interfaces and high-speed computers, numerical models have become the preferred method of evaluating regional groundwater flow. One widely used numerical model developed by the USGS is MODFLOW (McDonald and Harbaugh, 1988). For the purposes of this report, if an acceptable Department peer-reviewed MODFLOW model suitable for regional analysis is available, then it will be utilized to assist in analysis.

For this year's report the CEntral NEBraska Model (CENEB) was utilized for evaluating groundwater depletions in the Loup River and upper Elkhorn River subbasins of the Lower Platte River Basin. This model was developed by the Department and builds on previous modeling efforts in the basin. The documentation and model runs utilized in this evaluation are available at: ftp://dnrftp.dnr.ne.gov/Pub/FAB_Report/FAB_Report_2014/2014_FAB_Report_Data_Files/CENEB/ All other areas covered by this report were evaluated using analytical techniques that are described further below.

The analytical Jenkins (1968a) method for calculation of stream depletion factors (SDF) (Appendix C) lends itself best to the basin-wide aspect of the task described in this report. This method is based on simplifying assumptions and was built upon previously published equations.

For this report, the Jenkins method was used in the evaluation of the Lower Niobrara River Basin and portions of the Missouri Tributary Basins.

Modified versions of the Jenkins method have been developed to address more complex situations, such as the presence of boundary conditions (Miller and Durnford, 2005) and a streambed (Hunt, 1999 and Zlotnik, 2004). These modified methods require additional data that are generally not available for the basins in this evaluation. However, these data were available for the Blue River Basins (Bitner, 2008) and therefore utilized for that area in the evaluation.

In some areas of the state, use of the analytical method to determine the 10/50 area or the lag impact of groundwater pumping from wells was not completed. These areas typically lack information regarding the hydrologic connection between streams and aquifers. These areas were not evaluated in the current report.

4.2 Evaluating the Status of a Basin

To evaluate the status of a basin, the Department must evaluate the current and future water supplies of the basin. The following provides a general overview of the process used by the Department to evaluate the current and future water supplies in each basin as well as the specific step-by-step procedures implemented by the Department.

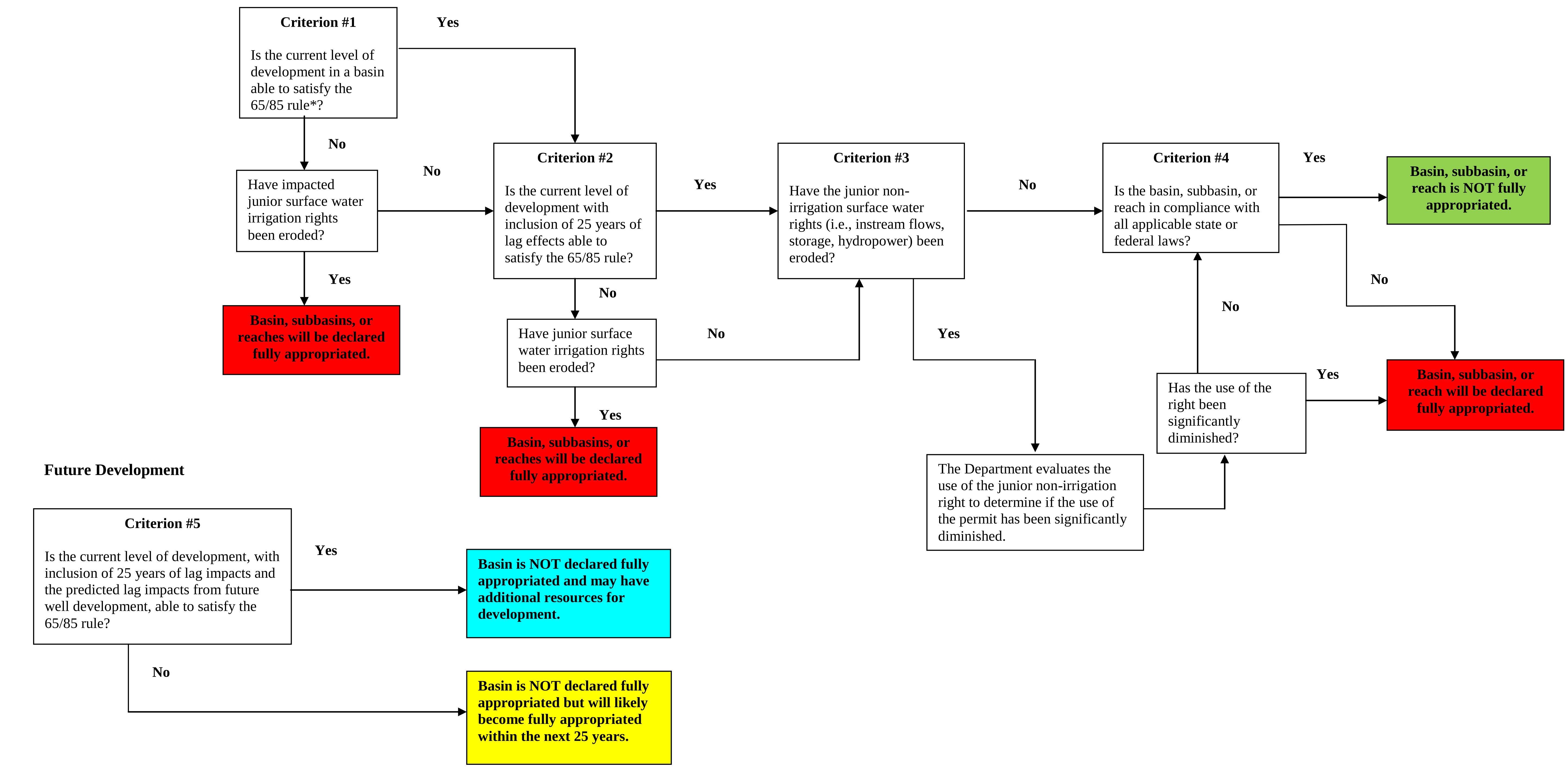
4.2.1 The Process of Determining if a Basin is Fully Appropriated

When determining the status of a basin, the Department evaluates five criteria: 1) that current levels of surface water and groundwater development, without consideration of lag impacts from wells, are able to satisfy the 65/85 rule; 2) that current levels of surface water and groundwater development, with consideration of 25-year lag impacts, are able to satisfy the 65/85 rule; 3) that erosion of non-irrigation surface water rights has not occurred, based on the standard of interference established by the Department; 4) that the basin, subbasin, or reach is in compliance with all applicable state and federal laws; and 5) that future development of groundwater in the basin (including lag impacts) will not cause the basin to be unable to satisfy the 65/85 rule.

If criteria one and/or two are not satisfied, then an additional test, the “erosion rule,” is applied to junior irrigation rights. This is used to evaluate whether the ability to divert water by the most junior surface water appropriation has been eroded. Methods for implementation of the erosion rule are discussed in detail in Section 4.2.4. Figure 4-1 illustrates the evaluation process for determining whether a basin is fully appropriated.

Failure to satisfy criteria one, two, three, or four will cause a basin to be declared fully appropriated. Failure to satisfy criterion five alone will not cause a basin to be declared fully appropriated, but such failure would indicate that future development may cause the basin to become fully appropriated if current development trends continue.

Evaluation of the Status of a Basin



- **In general terms, the 65/85 rule states that the surface water supply is deemed to be insufficient if, at current levels of development, the most junior irrigation right in a basin, subbasin, or reach has been unable to divert sufficient surface water over the last 25 to provide 85% of the amount of water a corn crop needs (the net corn crop irrigation requirement) during the irrigation season (May 1 through September 30), or if the most junior irrigation right in a basin, subbasin, or reach is unable to divert 65% of the amount of water a corn crop needs during the key growing period of July 1 through August 31.**

Figure 4-1. Basin evaluation flow chart.

4.2.2 Evaluation of Current Water Supplies

The first criterion assessed in order to determine if a basin is fully appropriated is the evaluation of whether the current water supply is sufficient to satisfy the 65/85 rule. The current water supply is estimated based on the most recent 25 period of streamflows (1993-2012). The following steps were taken to determine if current water supplies are sufficient to satisfy the 65/85 rule:

1. Determine the level of surface water administration that has occurred in each basin for the past 20 years.
2. Determine the crop irrigation requirement for junior irrigators subject to the administration.
3. Determine the number of days of diversion necessary to satisfy the 65/85 rule.
4. Compare the number of days available for diversion to the number of days necessary to satisfy the 65/85 rule.

Step 1: Determine the Level of Surface Water Administration in the Past 20 Years

The level of surface water administration is determined by Department records for calls for administration for the previous 20 years (1993-2012). The administration records are used to develop a 20-year average number of days for which administration was not occurring (days available for diversion). The days available for diversion are categorized based on the months in which they are available. Days that are available for diversion during July and August are categorized as available to meet the 65 percent portion of the 65/85 rule and days that are available for diversion during May, June, July, August, and September are categorized as available to meet the 85 percent portion of the 65/85 rule.

Step 2: Determine the Crop Irrigation Requirement

The net corn crop irrigation requirement (NCCIR) was developed to estimate the average minimum consumptive allocation of water necessary to yield a profitable corn crop to an individual operator. The NCCIR is used to determine the number of diversion days required for the most junior surface water appropriation to satisfy irrigation needs under the 65/85 rule. In developing the NCCIR, corn is used as the baseline crop because the most frequent beneficial use of water in all of the basins evaluated is for the irrigation of corn. The NCCIR accounts for the average evapotranspiration and average precipitation in an area and generally decreases from northwest to southeast across the state (Figure 4-2). The NCCIR distribution for each basin is set out in individual basin sub-sections. The method of developing the NCCIR is described in Appendix D.

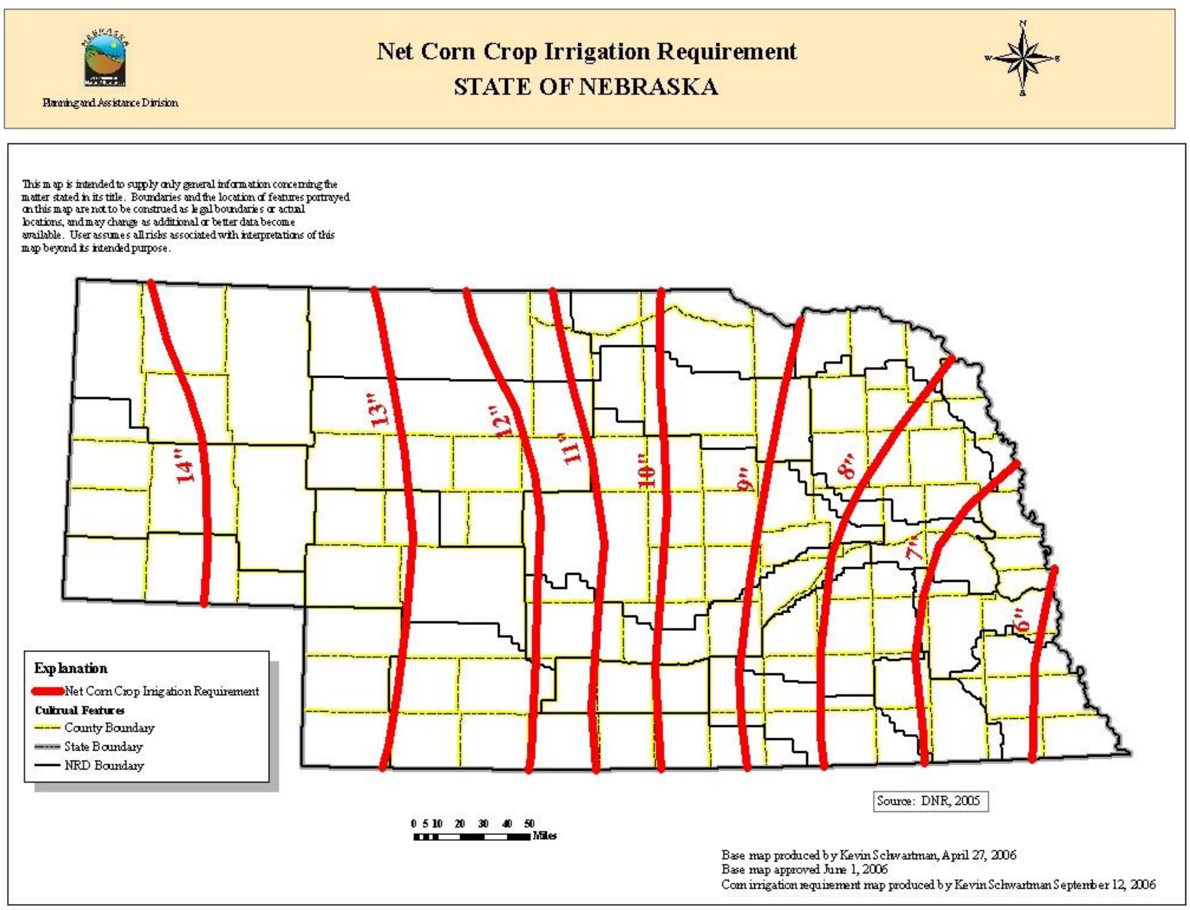


Figure 4-2. Net corn crop irrigation requirement (NCCIR).

Step 3: Determine the Number of Days Necessary for Diversion

To determine a junior irrigator's diversion requirements, the NCCIR is converted to the number of days necessary for an operator to divert water to yield a profitable corn crop using these assumptions: 1) a downtime of 10 percent, due to mechanical failures and other causes; 2) a diversion rate of one cubic foot per second (cfs) per 70 acres (or 0.34 inches perday), as this is the most common rate approved by the Department for surface water appropriations; and 3) an irrigation efficiency of 80 percent. The steps to determine the number of days necessary for a specific operator to divert include the following:

1. Determine the geographic location of the junior irrigator's diversion.
2. Interpolate between the NCCIR contours to determine the specific NCCIR at the junior irrigator's diversion.
3. Multiply the NCCIR by 0.65 and 0.85 to find the 65 percent and 85 percent requirements.
4. Calculate the gross irrigation requirement by dividing the values from step 3 by 0.8 (the irrigation efficiency).
5. Divide the gross irrigation requirement by 0.34 inches per day (rate of diversion) and by 0.9 (to account for downtime) to determine the number of days of diversion necessary for an operator.

$$\text{Number of days necessary} = \frac{\text{gross requirement}}{(0.34)(0.9)}$$

Step 4: Compare the Number of Days Available for Diversion to the Number of Days Necessary for the Junior Irrigator to Satisfy the 65/85 Rule

The results of the calculation in Step 3 are compared to the results of Step 1, the average number of days over the previous 20-year period (1993-2012) that surface water was available for diversion, to evaluate whether a basin is fully appropriated. If the average number of days available for diversion is less than the number of days necessary to meet either the 65 percent or 85 percent criteria, then the basin, subbasin, or reach may be declared fully appropriated.

This test is the first criterion in the five-tiered test described at the beginning of Section 4.2. If the basin satisfies this test, then the second criterion is evaluated: the addition of lag impacts from current development.

4.2.3 Evaluation of Long-Term Water Supplies with Current Levels of Development

The second criterion assessed to determine whether a basin is fully appropriated is to evaluate if the long-term water supply is sufficient to satisfy the 65/85 rule. The long-term water supply is estimated based on the most recent 20-year period of streamflows (1993-2012) and the lag impacts from current levels of well development. In those basins for which the appropriate geologic and hydrologic data were available and no numerical models exist, the following steps were taken to compute the lag impact from current development:

1. Define the groundwater boundary for the study area.
2. Extract all high-capacity wells with completion dates prior to December 31, 2012 from the Department's database.
3. Account for current year's development.
4. Estimate the volume of water pumped from each well.
5. Calculate the 25-year lag impacts.
6. Create lag-adjusted flow record.
7. Determine number of diversion days available.

An appropriate numerical model did not exist for calculating lag depletions in any of the basins evaluated. For areas in which the appropriate geologic and hydrologic data were available, lag depletions were calculated using the methods described in this sub-section. In those basins for which the appropriate geologic and hydrologic data were not available, the lag impacts were not calculated. In many of those cases, the number of days in which surface water is available for diversion far exceeds the number of days necessary to meet the NCCIR, and the final conclusion would likely not change even with the addition of lag impacts.

Step 1: Define the Study Area Boundaries

The study area surface water boundary for each river basin is defined by the watershed boundary. The study area groundwater boundary is defined by certain features that include the location of perennial baseflow streams, areas where the aquifers are present, and the location of glaciated areas.

Wells may be influenced by hydrologic boundaries (i.e., streams in other surface water basins). The methods used to account for these boundaries utilize image wells and superposition. These methods are further described in Jenkins (1968b).

Step 2: Identify High-Capacity Wells within the Study Area

In calculating lag impacts, the Department evaluates only high-capacity wells, considered to be those wells with a pumping rate of greater than 50 gallons per minute (gpm). High-capacity wells include active irrigation, industrial, public water supply, and unprotected public water supply wells (public water supply wells without statutory spacing protection). Other wells, such as decommissioned or inactive high-capacity wells, livestock watering wells, and domestic wells were not included because the Department's water well registration database is not complete for those well types. This omission is not considered significant because these wells use relatively small amounts of water. All active high-capacity wells with a completion date prior to December 31, 2012, were used in the analysis.

Step 3: Account for Current Year (2013) Development

Wells are not registered simultaneously with their completion date, so it was necessary to estimate the number of high-capacity wells that will be registered as constructed between January 1, 2013, and December 31, 2013. The first step in estimating the number of high-capacity wells for 2013 is to average the well development rates within a basin over the previous three-year period (2010-2012). Based on the rates, additional wells are randomly located geographically within the study area on soils that have been defined by the U.S. Department of Agriculture as irrigable. To ensure that land was available for development, a 1,400-foot-radius circle (slightly larger than the radius of an average center pivot) was drawn around each active high-capacity well existing in the Department's water well registration database. All lands within the circles were removed from the inventory of irrigable land available for development. In addition, all irrigable land areas of less than 40 acres that were available for new development were excluded. The wells extracted from the Department's water well registration database with a completion date prior to December 31, 2012, and those estimated to be developed in each basin in 2013 were then combined to serve as the basis for current well development.

Step 4: Estimate the Volume Pumped by Each Well

The volume pumped from a well for consumptive use (Qt) is determined by multiplying the NCCIR (see Section 4.2.2) by the number of acres irrigated by the well. The number of acres irrigated by each well was estimated to be 90 acres for reasons documented in Appendix E (DNR, 2005). Industrial and public water supply wells are treated the same as irrigation wells for this analysis.

Example:

If Location of well: Custer County, Nebraska

NCCIR requirement (from Figure 4-2): 11 inches/year

Number of acres served: 90 acres

Then Qt: 11 inches/year * 90 acres = 990 acre-inches/year or 82.5 acre-feet/year

Step 5: Calculate 25-Year Lag Impacts

In the Lower Niobrara River Basin and the Bazile Creek subbasin of the Missouri Tributary Basins, the Jenkins SDF methodology was utilized to estimate the 25-year lag impacts to streamflows due to current well development. The Jenkins SDF methodology allows for calculation of the streamflow depletion percentage of each well in the basin. The terms used in this methodology include the depletion percentage term and the dimensionless term, both defined below:

Depletion percentage term: v/Qt

Dimensionless term: $\frac{tT}{a^2S}$ or $\frac{t}{sdf}$

The goal of this analysis is to solve for the 'v' term, or the volume of stream depletion (in acre-feet/year) over the 25-year period. First, the dimensionless term is calculated using the following known variables:

- t is the time since the well was completed,
- T is the aquifer transmissivity,
- S is the aquifer specific yield,
- a is the perpendicular distance from the well to the nearest perennial stream.

Next, the dimensionless term is used to determine the percentage of depletion (v/Qt). For example, if the dimensionless term is equal to 0.7, then the depletion percentage is equal to 0.211, or 21.1 percent (see Figure 4-3).

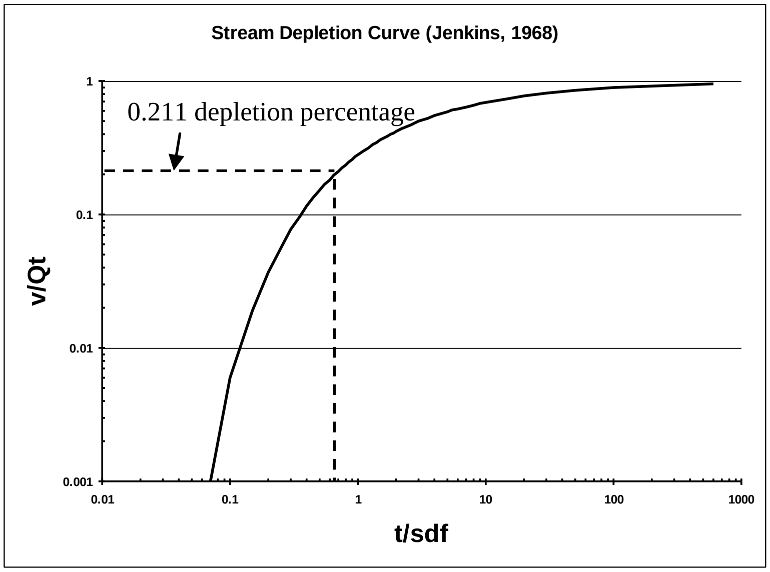


Figure 4-3. Determining depletion percentage (v/Qt) from the dimensionless term.

Finally, the stream depletion is calculated as follows:

v = Qt * percentage depletion

Where v = stream depletion in acre-feet/year

Qt = volume pumped in acre-feet/year

percentage depletion = value corresponding to the dimensionless term, from the graph in Figure 4-3

The depletion percentage is multiplied by the volume pumped, as calculated in Step Four, to determine total stream depletion. These results can be converted from annual acre-feet of depletion to cubic feet per second (cfs) by dividing by 724.46 (the conversion factor for acre-feet/year to cfs).

The next step is to calculate the 25-year lag impacts. The 25-year lag impacts for all current wells are calculated in a similar way, except that the time period for each well (t) is increased by 25 years (9,125 days). The depletion rate calculated for 2013 is subtracted from the depletion rate calculated for 2038 (25 years into the future) to determine the lag impacts. An example of this process is illustrated below (Table 4-1).

Table 4-1. Example calculation of 25-year lag impacts. The lag depletion is calculated by subtracting the rate of annual depletion in 25 years from the current rate of annual depletion.

<table>
<tr><th>Year</th><th>Cumulative Depletion (cfs)</th><th>Rate of Annual Depletion (cfs)</th><th>Lag (cfs)</th></tr>
<tr><td>2012</td><td>100</td><td rowspan="2">10</td><td rowspan="4">20</td></tr>
<tr><td>2013</td><td>110</td></tr>
<tr><td>2037</td><td>300</td><td rowspan="2">30</td></tr>
<tr><td>2038</td><td>330</td></tr>
</table>

Step 6: Create Lag-Adjusted Flow Record

The 25-year lag impacts from all current wells within a basin are summed to generate a total stream depletion value for the basin. A daily historic flow record is developed from stream gage data for the previous 20-year period to represent variations in climate and precipitation in the basin. The sum of the lag impacts is subtracted from the daily historic record to develop a new flow record, here termed the “lag-adjusted flow record.”

Step 7: Determine the Number of Days Available for Diversion

The lag-adjusted flow record is used to calculate the average number of days available for diversion to the most junior appropriator within the basin. The new average number of days available for diversion is compared to the number of days necessary for the most junior surface water appropriator to divert in the basin. If the number of days necessary to meet either the 65 percent or 85 percent criterion is less than the average number of days available for diversion, then the basin, subbasin, or reach may be declared fully appropriated.

4.2.4 Determining Erosion of Rights

If a basin has failed either the first or second criterion (described in Sections 4.2), then the next step in the Department's analysis is to apply what has been termed "the erosion rule" (457 NAC 24.001.01C). This rule takes into account the fact that appropriations may be granted even though water supplies may be insufficient at the time the appropriation is granted to satisfy the requirements of 65/85 rule. If an appropriation is unable to divert enough water to satisfy the requirements of the 65/85 rule, then the second evaluation is completed to determine if the right has been "eroded," i.e., if enough water was not available to satisfy the rule at the time the appropriation was granted.

In the event that the junior water right is not an irrigation right, regulation 457 NAC 24.001.01B states that the Department will utilize a standard of interference appropriate for the type of use to determine whether flows are sufficient for the use, taking into account the purpose for which the appropriation was granted.

The erosion rule is applied using historic streamflow data in a two-step process. The first step is to calculate the average number of days the most junior surface water appropriator would have been able to divert during the 20-year period before the priority date of the appropriation. The second step is to calculate the average number of days the same junior surface water appropriator has been able to divert during the previous 20 years (i.e., 1993-2012). If the number of days available for diversion has decreased, then the right has been eroded. When making these calculations, the Department takes into account the lag effect of wells existing at the time of the priority date, as well as lag impacts from current well development.

The steps for determining whether a right has been eroded are as follows:

1. Gather the daily streamflow records from the 20-year period prior to the appropriation being granted.
2. Gather the daily streamflow records for 1993-2012 to serve as the current 20-year period.
3. Determine the 25-year lagged groundwater depletions from wells existing on the date the junior surface water appropriation was granted, and subtract them from the daily streamflow record for the 20-year period prior to the granting of the appropriation.

4. Determine the 25-year lagged groundwater depletions from wells existing at the end of the current 20-year period (using methodologies described in Section 4.2.3), and subtract them from the daily streamflow record for the current 20-year period (1993-2012).
5. Assume that surface water administration would occur if the flow requirement of a senior surface water appropriation was greater than the depleted historical daily flow.
6. Conduct a month-by-month comparison of the average number of days available for the junior surface water appropriation to divert during the 20-year period prior to the appropriation and the average number of days available to divert during the current 20-year period.

If the average number of days available to the junior surface water appropriation for diversion during the current period (1993-2012) is less than the number of days available to the junior surface water appropriation for the 20-year period prior to the appropriation, then the appropriation is deemed to be eroded.

4.2.5 Evaluation of Compliance with State and Federal Laws

To evaluate compliance with state and federal law, it was determined that, currently, only the state and federal laws prohibiting the taking of threatened and endangered species could raise compliance issues that would trigger condition (c). The federal Endangered Species Act (ESA), 16 U.S.C. §§ 1530 *et seq.,* prohibits the taking of any federally listed threatened or endangered species of animal by the actual killing or harming of an individual member of the species (16 U.S.C. § 1532) or by the significant modification or degradation of designated critical habitat where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR § 17.3). The state Nongame and Endangered Species Conservation Act (NNESCA), *Neb. Rev. Stat*. §§ 37-801 *et seq.*, also prohibits the actual killing or harming of an individual member of a listed species and the destruction or modification of designated critical habitat. It was concluded that any reductions in flow that may occur as a result of not determining a basin, subbasin, or reach to be fully appropriated will not cause noncompliance with either federal or state law at this time in any of the basins evaluated.

4.2.6 Evaluating the Impacts of Predicted Future Development in a Basin

The Department is required by section 46-713 to project the impact of reasonable future development within a basin on the potential for fully appropriated status. The results of this analysis alone cannot cause a basin to be declared fully appropriated. The analysis does, however, provide an estimate of the effects of current well development trends on the basin's future status.

The steps necessary to calculate the impacts of future development on streamflows parallel the steps outlined in Section 4.2.3. The specific steps necessary to conduct an analysis of the impacts of future well development on the status of a basin are as follows:

1. Gather information on lag impacts of current wells (from calculations performed in Section 4.2.3).
2. Project the rate of future well development.
3. Incorporate projected future well development into the study area.
4. Calculate the depletions of projected future well development.
5. Subtract the depletions of projected future well development from the previous 20-year lag-adjusted flow record (1993-2012), and recalculate the number of days available for diversion for the most junior surface water appropriation.

Step 1: Gather Information on Lag Impacts of Current Wells

The lag impacts from current well development are determined as outlined in Section 4.2.3 above, and the lag-adjusted flow record developed in Step 6 of Section 4.2.3 is that discussed in this section. In using the lag-adjusted flow record, the 25-year lag impacts of current well development are accounted for, and the impacts from future wells can be removed directly from this new flow record.

Step 2: Project Future Well Development

When calculating impacts from future wells, the rate of future well development must be estimated. This estimation is completed by projecting the linear trend of current high capacity well development within a study area over the previous 10 years (2003-2012). The yearly estimated well development for the study area is equivalent to the slope of the trend line and takes into account known limitations, such as moratoriums, on well development.

Step 3: Incorporate Future Wells into the Study Area

The number of future wells estimated in Step 2 above must be incorporated into the study area. The future wells are located geographically within the study area by randomly placing each future well on a site where the soils have been defined by the U.S. Department of Agriculture as irrigable. To ensure that land was available for development, a 1,400-foot-radius circle (slightly larger than the radius of an average center pivot) was drawn around every existing well, and all lands already irrigated within the circles were removed from the inventory of irrigable lands that are available for development. In addition, all irrigable land areas of less than 40 acres that were available for new development were excluded.

Step 4: Calculate the Lag Impacts of Future Wells

Depletions from future wells are calculated following the same methodology outlined in Section 4.2.3. The depletions of future wells are calculated independently of current well development. The 25-year depletions from future well development are removed from the lag-adjusted flow record created in Step 6 of Section 4.2.3 to develop the future lag-adjusted flow record.

Step 5: Create a Historic Flow Record with Lag Impacts from Current and Future Well Development

The historic record, with the 25-year lag impacts from all current wells created at the end of Step 6 in Section 4.2.3 subtracted (i.e., the lag-adjusted flow record), is used as the starting point in developing the future lag-adjusted flow record. The depletions from future wells incorporated into the study area are calculated for each year through the 25-year period and subtracted from the lag-adjusted flow record.

The sum of the future depletions is subtracted from the lag-adjusted daily flow record for the period 1993-2012 to create a future adjusted flow record to account for all current well lag impacts and potential future well depletions. The future lag-adjusted flow record is then used to calculate the average number of days available for diversion to the most junior appropriator within the basin. This new future lag-adjusted flow record is compared to the number of days necessary for the most junior surface water appropriator to divert in the basin.

In those basins for which the appropriate geologic and hydrologic data were not available, the impacts of future well development were not calculated due to uncertainty of the degree of hydrologic connection. In many of those cases, the number of days in which surface water is available for diversion far exceeds the number of days necessary to meet the NCCIR, and the final conclusion would likely not change even with the addition of lag impacts.

4.3 Development of the 10/50 Areas

The 10/50 area is defined as the geographic area within which groundwater is hydrologically connected to surface water. A well constructed in the 10/50 area would deplete river flow by at least 10 percent of the water pumped over a 50-year period. The 10/50 areas are not dependent on the quantity of water pumped, but rather on each basin's geologic characteristics and the distance between each well and the stream.

4.3.1 Numerical and Analytical Models Used in Development of the 10/50 Areas

The Department reviewed available numerical models to assess their validity in defining the 10/50 area. The Department identified the CENEB model as being a valid numerical model for defining the 10/50 area for areas of the Lower Platte River Basin.

In other areas where appropriate geologic data exist (i.e., the Lower Niobrara Basin, portions of the Blue River Basins, and portions of the Missouri Tributary Basins), an analytical methodology was used to define the 10/50 area. The following steps were taken to calculate the extent of the 10/50 area:

1. Collect and prepare data (data will be provided by the Department upon request).
2. Evaluate available data to determine if the principal aquifer is present and if sufficient data exist to determine that a given stream reach is in hydrologic connection with the principal aquifer.
3. Complete calculations to delineate the 10/50 boundary for these basins.
4. Develop the 10/50 area.

Two analytical approaches were utilized to determine the extent of the 10/50 area. The Hunt Method (Hunt,1999) was used to determine the 10/50 area and to estimate groundwater depletions in the Blue Basins. This methodology was able to be used in the Blue Basins since streambed conductance data was provided by the Upper Big Blue Natural Resources District (Bitner, 2008). The Jenkins Method was used to determine the extent of the 10/50 area in portions of the Lower Niobrara River Basin and Bazile Creek subbasin of the Missouri Tributary Basins. In all other areas, where sufficient data do not exist or where the principal aquifer is not present, the 10/50 area could not be determined at this time.

Step 1: Data Preparation

The following data are necessary for determining the extent of the 10/50 area:

- Aquifer transmissivity,
- Aquifer specific yield,
- Locations of perennial streams,
- Point grid of distances to streams,
- Streambed conductance (to apply the Hunt Method; only available in the Blue Basins).

The aquifer properties used in the study were found in the report "Mapping of Aquifer Properties – Transmissivity and Specific Yield – for Selected River Basins in Central and Eastern Nebraska" published by the Conservation and Survey Division (CSD, 2005). The location and extent of perennial streams were found in the permanent streams GIS coverage available from the USGS National Hydrography Dataset. The main stems of each river and of their perennial tributaries were included in the calculations for individual basins.

A point grid with a spacing of one mile was developed to identify specific distances from the stream and to store those locations that were within the 10/50 area.

Step 2: Identify Principal Aquifers and Hydrologic Connection to Perennial Streams

The extent of hydrologic connection between aquifers and streams was primarily determined from maps generated by the Conservation and Survey Division (CSD, 2005). Supporting evidence from other published reports may also be used in some cases to delineate the extent of hydrologic connection between aquifers and streams. This information is referenced where used.

Step 3: Perform Jenkins SDF Calculations

In the Lower Niobrara River Basin and the Bazile Creek subbasin of the Missouri Tributary Basins, the Jenkins SDF method was used. The Jenkins SDF method utilizes the following two terms, for which solutions are derived graphically using the curve shown in Figure 4-4.

Depletion percentage term: v/Qt

Dimensionless term: $\frac{t}{sdf}$

Where v = volume of stream depletion during time t

Qt = net volume pumped during time t

t = time during the pumping period since pumping began

$$sdf = \frac{a^2 * S}{T}$$

Where a = perpendicular distance between the well and stream

S = average specific yield of the aquifer between the well and the stream

T = average transmissivity of the aquifer between the well and the stream.

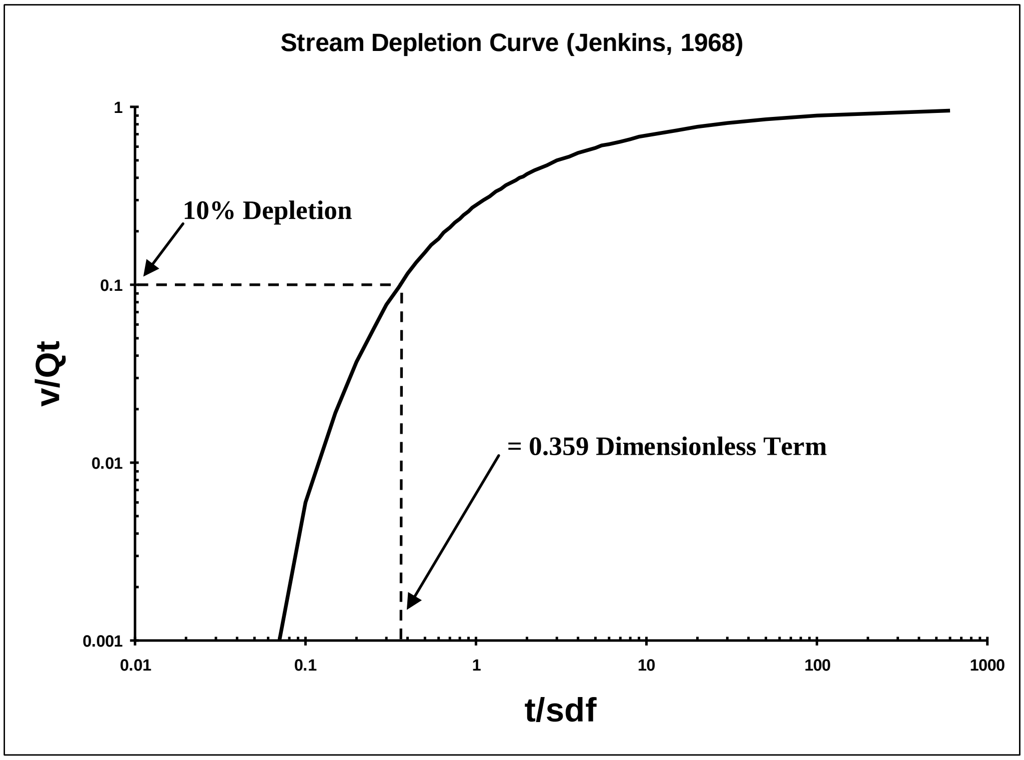


Figure 4-4. Stream depletion curve from Jenkins (1968). The dimensionless term will equal 0.359 when the depletion percentage is equal to 10 percent. The aquifer properties (transmissivity and specific yield) at each grid point and the distance of each grid point from the nearest perennial stream will be utilized to calculate the dimensionless term.

Figure 4-5 illustrates an example of the data used in the determination of the dimensionless term at each point. The known values for the 10/50 calculation are as follows:

- t is 50 years, or 18,262 days,
- T is the aquifer transmissivity,
- S is the aquifer specific yield,
- a is the perpendicular distance from the grid point to the nearest perennial stream.

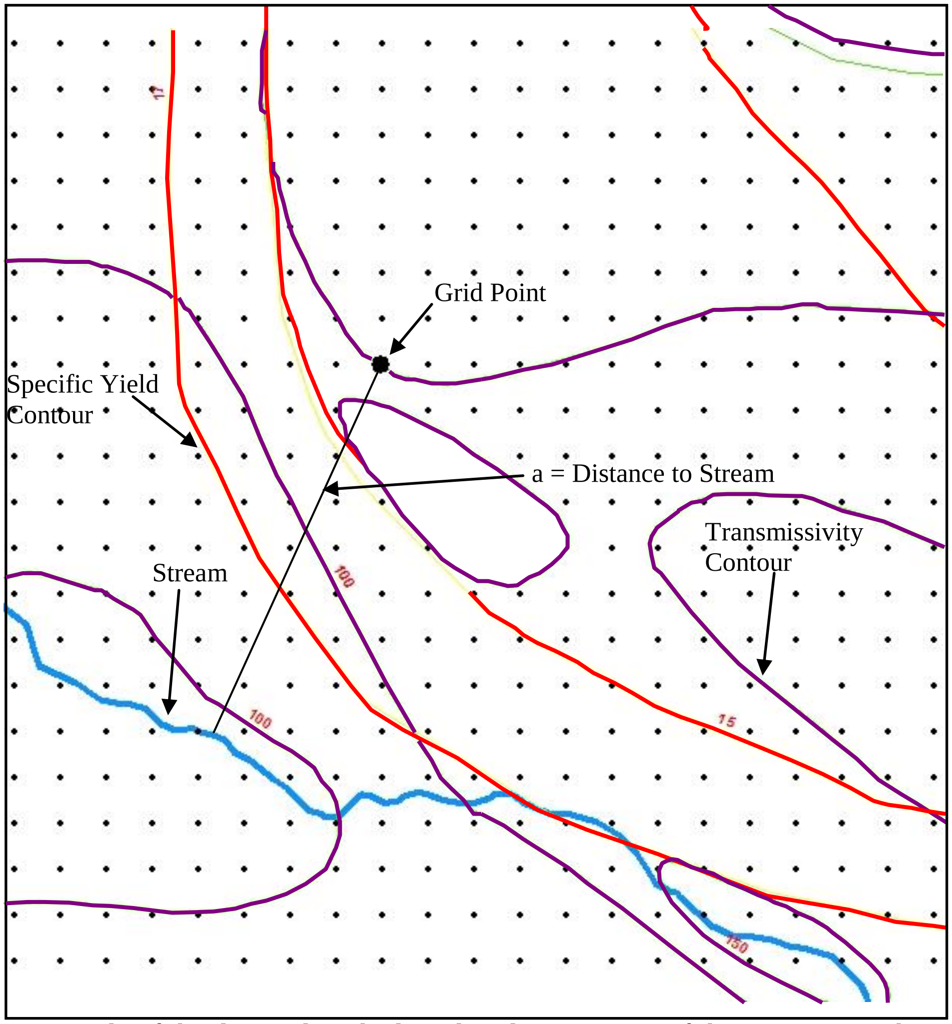


Figure 4-5. An example of the data and method used in determination of the 10/50 area. The purple and red lines are isolines (constant value along that line). Transmissivity and specific yield values for individual points are interpolated between the two nearest contour lines.

Step 4: Developing the 10/50 Area

Once the value for the dimensionless term is derived, those grid points with a dimensionless term value greater than 0.359 are included as part of the 10/50 area. All points that meet this requirement are merged to develop the complete 10/50 area for the basin.

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