4.0 METHODOLOGY

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

1. The first sub-section (4.1) outlines the legal requirements established in § 46-713 of the Ground Water Management and Protection Act (Act) (*Neb. Rev. Stat.* §§ 46-701 through 46-754) and 457 *Neb. Admin. Code* (NAC) ch. 24 as they relate to the analysis.
2. The second sub-section (4.2) discusses the specific methods implemented by the Department to calculate the extent of the hydrologically connected area (10/50 area).
3. The third sub-section (4.3) provides the overall procedure for determining whether a preliminary determination of fully appropriated is required.
4. The fourth sub-section (4.4) describes an additional statutorily required analysis used to assess how the preliminary determination reached in sub-section three would change if no additional legal constraints were imposed on future development.

4.1 Legal Requirements

The methodologies used for evaluation within this report were developed to meet the requirements of § 46-713 of the Act. The determination of fully appropriated is guided not only by § 46-713 of the Act, but also by Department regulations, Chapter 24 of Title 457 of the Nebraska Administrative Code. The two documents work in partnership to provide clarity and transparency to the process by which a basin may be determined to be fully appropriated. The statute specifies the framework upon which the regulations develop further definition. § 46-713 sets forth the following criteria, requiring the Department to: 1) describe the nature and extent of surface water 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. Chapter 24 of Title 457 goes on to provide four (4) significant guideposts for the development of methodologies used to determine the appropriated status of a basin. The first provides specification for the preliminary determination of fully appropriated, the second for the final determination of fully appropriate, the next for the determination of the hydrologically connected area and the fourth for the type of scientific data and information that will be considered when making a fully appropriated determination. Each guidepost is further described below.

4.1.1 Determination of Fully Appropriated (§46-713(3) and Regulation 457 NAC 24.001)

Neb. Rev. Stat. §§ 46-713 (3) 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.

Regulation 457 NAC 24.001 provides for a two-step process for the Department to reach a determination of fully appropriated. The first step is a preliminary determination based on an annual evaluation of the balance between water supplies and water uses/demands. The second step is to hold public hearings and review information provided at the hearings and consider additional facts (scientific information, current integrated management planning efforts, and associated management areas and controls) available subsequent to the preliminary determination. It is only after following both of these steps that the Department would reach a final determination that a basin, subbasin, or reach is fully appropriated.

4.1.1.1 Preliminary Determination of Fully Appropriated

Regulation 457 NAC 24.001 more specifically defines how Neb. Rev. Stat. § 46-713(3) is applied to reach a preliminary conclusion regarding a basin's appropriation status. The regulation states that the Department shall reach a preliminary conclusion that a river basin, subbasin, or reach is fully appropriated based on the Department's annual evaluation, if it is determined that Total Use of hydrologically connected groundwater and surface water exceeds the Basin Water Supplies for the period of June 1 through August 31, inclusive, or the period of September 1 through May 31, inclusive, over the representative period of record, which the Department determines is most appropriate for this purpose and thereafter utilized by the Department to conduct the analysis.

As a final step in the Department's preliminary determination, the Department is also required, pursuant to *Neb. Rev. Stat.* §§ 46-713 (1) (b) to assess how its preliminary conclusions, based on current development, might change by predicting future development. The predictions of future development account for existing development trends and project development that may be added in the next twenty-five years. Because the Department does not use this portion of the evaluation in the determination of basin status, no further specifics are defined in Department Rules and Regulations.

4.1.1.2 Final Determination of Fully Appropriated

The Department will reach a final determination that a basin, subbasin, or reach is fully appropriated if the Department determines that, based upon its annual evaluation (the criteria established in 457 NAC 24.001.01A-D) and information presented at hearings held subsequent to a preliminary determination of fully appropriated, that the following conditions apply:

1. That no additional information relevant to its annual evaluation has been identified that would result in the Department reaching a different conclusion than that reached pursuant the preliminary determination;
2. That all of the natural resources districts in the area preliminarily determined to be fully appropriated have not initiated a voluntary integrated management planning process, designated a management area for which a purpose is the integrated management of hydrologically connected groundwater and surface water, and the natural resources districts and Department have not taken more than three years to complete such integrated management plan(s); or
3. That in the event that an integrated management plan(s) has been completed, appropriate limitations on new water uses are not included in such integrated management plan(s) inclusive of controls on such new uses pursuant to Neb. Rev. Stat. § 46-739 (6)(b), and such integrated management plan(s) does not include a plan to monitor water uses in a manner consistent with 457 NAC 24.001.01A-D.

4.1.2 Determination of Hydrologically Connected Areas (§46-713(1)(a)(ii) and Regulation 457 NAC 24.001.03)

In accordance with §46-713(1)(a)(ii) the Department must determine the geographic area within which surface water and groundwater are hydrologically connected. Regulation 457 NAC 24.001.03 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 ten percent of the amount of water the well could pump over a fifty-year period (10/50 area). The 10/50 area serves as the initial area that would be subject to preliminary stays when a basin is determined to be fully appropriated. If agreed to by both the Department and participating NRD, the 10/50 area can be modified during the development and completion of an integrated management plan.

4.1.3 Utilization of the Best Available Science in the Annual Evaluation (§46-713(1)(d) and Regulation 457 NAC 24.002)

In accordance with §46-716(1)(d), 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. All references to "best available science" included in this document will be detailed in the Department's annual evaluation. These references will include such items as model datasets and documentation on specific processes and data used by the Department. 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. This information includes:

1. Department records on the regulation of surface water appropriations;
2. Department maps of surface water appropriations;
3. Department Hydrographic Reports;
4. Department and United States Geologic Survey stream gage records;
5. Department's registered well data base;
6. Technical hydrogeological reports and publications subject to Department peer review;
7. Department reviewed groundwater models and resulting model outputs;
8. Certified irrigated acres provided by the Natural Resources Districts;
9. Water use information provided by other state agencies, natural resources districts, irrigation districts, reclamation districts, public power and irrigation districts, mutual irrigation companies, canal companies, municipalities, and other water users; and
10. Other information deemed appropriate by the Department for the purpose of conducting the determination.

4.2 Determination of Hydrologically Connected Areas (10/50 areas)

The overall Department evaluation procedures compare the Basin Water Supply (water supply) to the Total Use (water uses/demands). The comparison of the Basin Water Supply and Total Use allows for a comparison of the balance between water supplies and water uses. Both Basin Water Supply and Total Use rely upon a series of calculations, which are outlined in section 4.3. To provide context for the remaining sections of the document (4.3 and 4.4), this section outlines the process used to determine the 10/50 area. The determination of this area is essential to calculating consumptive uses associated with groundwater development (a component of the Total Use).

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

In determining the best available science, the Department reviews available numerical and analytical models to assess their validity in defining the 10/50 area. The Department will determine and utilize the best available science for each basin, subbasin, or reach evaluated. When numerical models are utilized to determine the extent of the 10/50 area for a given stream, the following steps are taken:

1. Prepare numerical model files, as needed, so that at least a 50-year time span is simulated.
2. Prepare and execute a 50-year (or more) baseline simulation in which pumping is not increased above the levels defined in the calibrated model version.
3. Prepare and execute a series of 50-year (or more) simulations, in which additional pumping is defined for a single selected cell in the model for the entire simulation period (different cell locations are selected for each run in the series).
4. Calculate the difference in simulated groundwater contributions to surface discharges over 50 years between the baseline (Step 2) and analysis (Step 3) runs as a percentage of the total volume of additional water pumped over that same period.
5. Assign the percentage calculated in Step 4 to the cells in which additional pumping was defined in Step 3.
6. Delineate the 10/50 area for the modeled basin, subbasin, or reach.

In areas where an appropriate regional numerical model has not been developed, but where appropriate geologic data exist, an analytical methodology may be applied. The following steps are utilized to calculate the extent of the 10/50 area when applying an analytical approach:

1. 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.
2. Collect and prepare data.
3. Complete calculations to delineate the 10/50 boundary for these basins.
4. Develop the 10/50 area.

Two analytical approaches have been identified by the Department for utilization in determining the extent of the 10/50 area. The Hunt Method (Hunt, 1999[1]) is the preferred analytical approach to apply when appropriate numerical models are not available; however, the Hunt Method requires spatially distributed data on streambed conductance. When such streambed conductance data does not exist, the Department utilizes the Jenkins Method (Jenkins, 1968[2]). The Jenkins Method is similar to the Hunt Method with the exception that streambed conductance data is not required. The application of these analytical approaches is outlined through the following steps:

Step 1: Identify Aquifers that are in Hydrologic Connection to Perennial Streams

The locations of aquifers in hydrologic connection to perennial streams are determined using the best available science. The types of information used in this

[1] Hunt, B. 1999. Unsteady Stream Depletion from Ground Water Pumping, *Ground Water*, Vol. 37 (1): 98-102.

[2] Jenkins, C.T. 1968a. "Computation of Rate and Volume of Stream Depletion by Wells." In *Techniques of Water Resources Investigations*. U.S. Geological Survey, Book 4, Chapter D1. Washington, D.C.

assessment include the distribution of groundwater aquifers, perennial streams, and regional water table maps. This information is referenced where used.

Step 2: Data Preparation

Once aquifer locations are identified, availability of additional information must be evaluated. The following data are necessary for determining the extent of the 10/50 area using analytical approaches:

- Aquifer transmissivity,
- Aquifer specific yield,
- Locations of perennial streams,
- Point grid of distances to streams,
- Streambed conductance (to apply the Hunt Method).

Data on aquifer properties (transmissivity and specific yield) will be identified using the best available science. The location and extent of perennial streams will be identified from the perennial streams GIS coverage available from the USGS National Hydrography Dataset. The point grid will be spatially refined to a one- mile grid so that specific distances from the stream to grid nodes can be identified and stored.

Step 3: Analysis

The analysis of locations for determining if a hydrologic connection (ten percent depletion in fifty years) exists is performed following the calculation procedures established through the Hunt Method (when streambed conductance data are available) or the Jenkins Method.

4.3 Procedure for the Evaluation of the Status of each Basin

To evaluate the status of a basin, the Department must evaluate the near-term and long-term water supplies of a basin, subbasin, or reach. The following provides an overview of the process used by the Department to evaluate the near-term and long-term water supplies in each basin, subbasin, or reach. When determining the status of a basin, the Department evaluates three criteria: 1) that the Total Use from current levels of surface water and groundwater development within the hydrologically connected area do not exceed available Basin Water Supplies for the period of June 1 through August 31, inclusive, over the representative period of record; 2) that the Total Use from current levels of surface water and groundwater development within the hydrologically connected area do not exceed available Basin Water Supplies for the period of September 1 through May 31, inclusive, over the representative period of record; and 3) that the basin, subbasin, or reach is in compliance with compacts, decrees, agreements, and all applicable state and federal laws.

If any of these three criteria are not satisfied, then the Department will make a preliminary determination that such basin, subbasin, or reach is fully appropriated. This preliminary determination will be evaluated pursuant to 457 NAC 24.001.02 to determine if a final determination of fully appropriated is warranted.

The discussion below describes the components the Department will use to determine the Basin Water Supply and Total Use of a basin, subbasin, or reach. The Basin Water Supply and Total Use components are described in sections 4.3.1 and 4.3.2, respectively. It is through the comparison of these two items, the Basin Water Supply and the Total Use, that a preliminary determination is made regarding the fully appropriated status of a basin, subbasin, or reach. Section 4.3.3 describes the two comparisons that will be made by the Department to determine whether or not a basin, subbasin, or reach is fully appropriated. Section 4.3.4 describes the evaluation of basin status performed by the Department to meet the requirements of criteria three (3) concerning compliance with state and federal laws.

4.3.1 Determination of Current Basin Water Supplies

The Basin Water Supply represents the water supply that is available for Total Use within a river basin, subbasin, or reach. If no surface water or groundwater use was occurring by humans in a basin, the Basin Water Supply would be represented by the streamflow data captured at a streamflow gaging station. However, streamflow is impacted by human activity; therefore, to calculate a total Basin Water Supply, three water supply components are added together. These three water supply components (gaged streamflow, surface water consumptive uses, and groundwater depletions) are discussed in detail below.

4.3.1.1 Streamflow

The Department has identified the long-term stream gages that it will utilize in its annual evaluation. Figure 1 illustrates the locations of these gages and subbasin areas upstream of each of those gages. The subbasins associated with each of these gages represent the level of refinement that the Department will utilize, within its annual evaluation, for those areas not currently designated as fully or overappropriated.

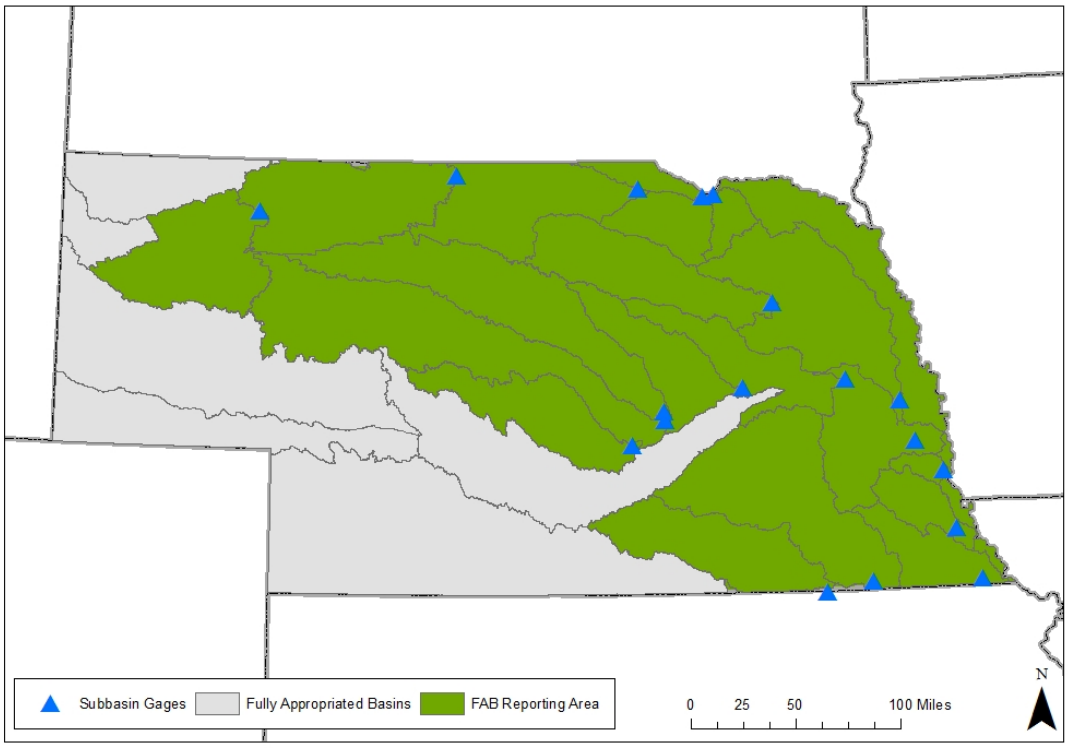

Figure 1. Subbasins to be evaluated through the Department's Annual Evaluation

4.3.1.2 Surface Water Consumptive Uses

Surface water consumptive uses are intended to reflect all direct diversions of streamflow for consumptive uses minus the portion of the diversion that returns to the stream (return flow). Return flow can occur as direct runoff (e.g., overland flow or canal spillways) or through recharge to the aquifer, eventually returning to the stream as baseflow. Surface water uses can be estimated through the use of measured diversion data combined with assumptions regarding return flow, or through the use of irrigated acreage data and assumptions regarding crop irrigation requirements and availability of streamflow (e.g. stream gage data, water administration records, etc.). The specific approach used to assess a point of diversion will rely on the best available science and data.

4.3.1.3 Groundwater Depletions

Groundwater is largely derived from recharge from precipitation and, in the absence of groundwater pumping, ultimately discharges from the aquifer as baseflow to a river or as direct evapotranspiration from the water table (typically in riparian zones). Generally speaking, over the long term, the discharge to the aquifer is equal to the aquifer recharge. Groundwater use changes this equation and reduces the amount of recharge that ultimately discharges to the stream. This difference in stream baseflow is termed "stream

depletion" and can be determined with groundwater modeling tools (analytical or numerical).

Groundwater depletions are calculated by evaluating the effects of groundwater pumping by high capacity wells (greater than 50 gallons per minute), and summarizing those impacts for each given basin, subbasin, or reach. In performing this analysis the Department relies on the best available scientific information, including groundwater models which have been reviewed by the Department.

4.3.1.4 Final Basin Water Supplies

The final step in determining the Basin Water Supply is to sum the streamflow, surface water consumptive use, and groundwater depletions for the period of record and then statistically assess this summation to determine if any trends and/or cycles exist. Cycles that are of interest are the natural dry and wet hydrologic periods that occur in the river basins across Nebraska. To ensure that any trends in data resulting from the dry/wet hydrologic cycles do not bias the analysis, two types of statistical analyses are performed to determine an appropriate, unbiased period of record for the evaluation.

The first process is the utilization of an autocovariance analysis. This process ensures that the representative period used for the evaluation includes the most recent pattern of wet and dry conditions, and that it is not reflective of other underlying trends or causal mechanisms. The autocovariance analysis of the Basin Water Supply provides a measure of self-similarity of the time-series data. In other words, it provides a measure of the time periods over which patterns tend to repeat. The resulting autocovariogram/autocorrelagram plots the coefficients, which range from -1 to 1, that represent the degree of correlation between the time-series and a time-shifted version of itself. This process aids in identification of the representative period that contains the most recent wet and dry conditions.

In order to ensure that the resulting evaluation is not biased by trends resulting from factors beyond the components of the Basin Water Supply, a trend analysis is performed. Once the representative period of record is identified, a Kendall Tau test is performed on that period of record. The Kendall Tau test, a simple non-parametric test statistic, can be used to identify statistically significant trends within a dataset by measuring concordance. This test statistic ranges from -1 to 1, testing the null hypothesis of zero association. If the Kendall Tau test statistic does not suggest the presence of an underlying trend, then the evaluation process continues, if the test suggests that a trend is present, then the representative period will be reevaluated.

4.3.2 Determination of Total Uses

The Total Use, in conjunction with the Basin Water Supply, is essential to determining the preliminary status of a basin. The following defines Total Use, and gives generalized methods for calculating each component that comprises the Total Use.

The Total Use of water within a basin, subbasin, or reach is derived from six main categories of water use: 1) consumptive water demands for hydrologically connected high capacity (greater than 50 gallons per minute) groundwater well pumping; 2) consumptive water demands for surface water uses; 3) the net water determined to be necessary to deliver streamflows to meet consumptive demands of surface water; 4) streamflow available to meet instream flow appropriations at the time the appropriation was granted (accounting for all development in place at such time the appropriation was granted); 5) instream flow demands for hydropower operations; and 6) the proportionate amount of Basin Water Supplies necessary to meet demands downstream of a given basin, subbasin, or reach. This section provides a further description of these six categories of water demands.

4.3.2.1 Demands on Water Supplies for Groundwater Consumptive Use

The consumption of hydrologically connected water supplies due to groundwater pumping is derived through evaluating high capacity (wells pumping greater than 50 gallons per minute) well development within the 10/50 area. The goal of this portion of the analysis is to identify the level of groundwater consumption associated with current levels of development within the 10/50 area. The broad categories of use evaluated as part of this analysis are: 1) irrigation; 2) municipal (not inclusive of sole source domestic wells); and 3) industrial.

Estimates of the level of consumption of water necessary to meet irrigation use are calculated through evaluating current levels of irrigated acreage development and crop distributions, and multiplying those land uses by the crop water needs for the representative period of record being analyzed. The methods used to determine irrigated acreage development, crop distributions, and crop consumption estimates rely on the best available scientific information.

The approach used to estimate municipal water use follows one of two methods. The first method (preferred when the data is available) utilizes available information on municipal groundwater pumping and subsequent return to a stream (if applicable). Thus, this method calculates a net consumption by taking the difference of the amount of water pumped and the amount of water returned through a municipal system. If no water is returned, as in the case of a full retention system, then the pumped amount is assumed to be 100 percent consumed.

The second method utilizes current population statistics and an appropriate estimate of per capita use. This method is accomplished by multiplying the current level of population by the appropriate level of per capita consumption. The appropriate level of per capita consumption is derived based on the location of the given municipality and relies on the best available scientific information.

The approach used to estimate industrial water use is based on identifying the number of high capacity industrial wells and multiplying the number of industrial sites by an estimated water use associated with typical industrial water use. The methods for

estimating typical industrial water use will rely on the best scientific information available.

To develop a final total estimate of demands on water supplies for groundwater consumptive use in the 10/50 area, the totals from these three categories of use (irrigation, municipal, and industrial) are summed.

4.3.2.2 Demands on Water Supplies for Surface Water Consumptive Use

The demands on water supplies for surface water consumptive use of hydrologically connected water supplies is derived through evaluating active points of diversion in each basin, subbasin, or reach. This portion of the analysis identifies the level of demand on water supplies by surface water consumptive use due to current levels of surface water development. The broad categories of use evaluated as part of this analysis are: 1) irrigation; 2) municipal (not inclusive of sole source domestic); and 3) industrial.

Estimates of the level of consumption of water necessary to meet irrigation use are calculated through evaluating current levels of surface water irrigated acreage development, crop distributions, and multiplying those land uses by the crop water needs for the period of record being analyzed. The methods used to determine irrigated acreage development, crop distributions, and crop consumption estimates rely on the best available scientific information.

The approach used to estimate municipal water use follows one of two methods. The first method (preferred when the data is available) utilizes available information on municipal water diversions and subsequent return to a stream (if applicable). Thus, this method calculates a net consumption by taking the difference of the amount of water diverted and the amount of water returned through a municipal system. If no water is returned, as in the case of a full retention system, then the diverted amount is assumed to be 100 percent consumed.

The second method utilizes current population statistics and an appropriate estimate of per capita use. This method is accomplished by multiplying the current level of population by the appropriate level of per capita consumption. The appropriate level of per capita consumption is derived based on the location of the given municipality and relies on the best available scientific information.

The approach used to estimate industrial water use is based on identifying the number of points of diversion and multiplying them by an estimated water use associated with typical industrial water use. The methods for estimating typical industrial water use will rely on the best scientific information available.

4.3.2.3 Demands on Water Supplies for the Net Water Determined to be Necessary to Deliver Streamflows to Meet Consumptive Uses of Surface Water

The demands on water supplies for the net water determined to be necessary to deliver streamflows to meet consumptive uses of surface water are derived through an evaluation of the conveyance structures (canals, pumps, etc.) associated with the delivery of surface water for consumptive use. In many cases, such as large unlined canals, it is important to assess this component of water demands as this is the means by which water is available for consumption. In conducting this evaluation, it is also recognized that in certain areas a portion of this demand is met by streamflows that are returned into the stream from upstream uses and those streamflows are not returned to the stream within the same time period (i.e., June through August or September through May) or within the same year. The specific value that will be used to represent this component of demands will be based on the best available science.

4.3.2.4 Demands on Water Supplies for Instream Flows

Instream flow use is determined in areas where existing instream flow appropriations are currently permitted. The evaluation of instream flows is slightly different than other water uses in that an additional step must be taken to assess the full impacts of the level of development at the time the appropriation was granted. *Nebraska Revised Statute* § 46-713 (3)(a) states that subbasins shall be deemed fully appropriated when:

> "…….***then-current*** *uses of hydrologically connected surface water and ground water in the river basin, subbasin, or reach cause or will in the reasonably foreseeable future cause (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 and the beneficial or useful purposes for which,* ***at the time of approval****, any existing instream appropriation was granted.……".*

Instream flows are incorporated into the analysis for those areas where surface water appropriations are currently in place. Instream flows represent a "non-consumptive" category of water demand, thus water supplies available to meet instream needs may also be used to meet other non-consumptive demands such as hydropower or induced recharge. Instream flow demands are incorporated into the analysis in a manner that takes into account the level of development (both surface water and groundwater) that was in place at the time an appropriation was granted.

Instream flow demands are represented through a three-step process. The first step consists of adding the total groundwater depletions to the daily streamflow values at the point of the appropriation for the representative period. The second step consists of subtracting the consumption associated with levels of groundwater development in place at the time of the appropriation from the daily flows created in step 1 (ensuring that all values less than zero, are set to zero). The third and final step is to truncate the daily

flows to those amounts of water appropriated on each day. An example of this process is provided below.

Step1: Streamflow = 1,800 cubic feet per second (cfs)
Groundwater depletion = 200 cfs
Adjusted streamflow = 1,800 + 200 = 2,000 cfs

Step 2: Adjusted streamflows resulting from step one = 2,000 cfs
Consumption associated with groundwater development in place at the time of appropriation = 500 cfs
Step 2 adjusted streamflows = 2,000 -500 = 1,500 cfs

Step 3: Rate of instream flow provided for in the appropriation = 1,800 cfs
Final instream flow demand on that day = 1,500 cfs

If the rate of appropriated instream flow would have been less than the 1,500 cfs value (i.e., 1,000 cfs) in the example above, then the final instream flow demand on that day would have been truncated at that value (i.e, 1,000 cfs).

4.3.2.5 Demands on Water Supplies for Hydropower

Demands on water supplies to support hydropower water uses are represented in the analysis as a non-consumptive use. As mentioned in the previous section (Demands on Water Supplies for Instream Flows), water supplies available to meet non-consumptive uses are analyzed to ensure that water demands are not unnecessarily being duplicated. This analysis is performed through a comparison of both hydropower demands and instream flow demands where they coexist.

Hydropower demands are represented by evaluating the water supplies that were diverted on a daily basis through the representative period, and the groundwater depletions to those daily values when the diversion was operational and the full capacity of the diversion was not realized. An example of this process is provided below.

Step1: Streamflow = 1,800 cubic feet per second (cfs)
Groundwater depletion = 200 cfs
Adjusted streamflow = 1,800 + 200 = 2,000 cfs

Step 2: Daily rate of diversion for hydropower = 1,800 cfs
Final hydropower demand on that day = 2,000 cfs

If the rate of diversion for hydropower were equal to zero then that days demand is set equal to zero. Additionally, if the appropriated rate of diversion for hydropower would have been less than the 2,000 cfs value (i.e., 1,000 cfs) in the example above, then the final hydropower demand on that day would have been truncated at that value (i.e, 1,000 cfs).

4.3.2.6 Demands on Water Supplies for Meeting Downstream Water Needs

A portion of Basin Water Supplies are necessary to meet downstream water demands. To recognize and account for this in the evaluation, that portion of Basin Water Supply at each gage required to meet downstream water uses is estimated and applied at the upstream gage. To facilitate the allocation of downstream demands, only main-stem channel water demands are utilized. Non-consumptive and consumptive uses are considered separately, as non-consumptive uses are typically available to meet multiple downstream water demands.

Downstream non-consumptive use demands are computed as the ratio of Basin Water Supplies at the evaluation point (basin, subbasin, or reach outlet gage) to all of the other downstream evaluation points. This calculation is necessary to determine what percentage of flow in the basin, subbasin, or reach contributes to subsequent downstream basins, subbasins, or reaches. Examples of this process are outlined in Section 9.7.4 of the "Fully Appropriated Evaluation Methodology Development" Technical Memorandum published by HDR Engineering, Inc. and The Flatwater Group[3]. The process is repeated at all downstream evaluation points. The percentages identified at each evaluation point are multiplied by each non-consumptive use demand at that evaluation point. The non-consumptive use demand represents the amount of flow that downstream basins, subbasins, or reaches could reasonably expect to receive based on the upstream contribution. Therefore, the upstream basin is only assigned its percentage of the downstream non-consumptive use demand and no more. The next step in this process is to perform any necessary reductions in non-consumptive water demands to account for other non-consumptive uses already represented in the demands. Further discussion of this process is outlined in the Technical Memorandum (HDR, 37-41). It is important to note that this amount is not cumulative. If the upstream basin provides its portion to meet the largest downstream non-consumptive use demand, sufficient flow would be provided to meet all of the downstream non-consumptive use demands.

In contrast to downstream non-consumptive use demand, the calculation of downstream consumptive use demand is cumulative. The upstream basin, subbasin, or reach is assigned a portion of the downstream water demands on the main-stem channel, or in the case of downstream groundwater demands, that portion within the 10/50 area of the main-stem channel. The upstream basin would not be assigned the entire downstream water demand. Rather, the upstream subbasin or reach is only assigned the percentage of downstream water demands equivalent to its contribution to the entire basin's Basin Water Supply.

4.3.3 Determination of Balance between Current Water Supplies and Uses

Once the Basin Water Supply and the Total Use are determined, the comparison of the two components can be completed. To recognize the impact that timing has on the

[3] HDR Engineering, Inc. and The Flatwater Group. "Fully Appropriated Evaluation Methodology Development." November 2011.
http://dnr.ne.gov/IWM/Reports/FinalFullyAppropriatedEvaluationRefinementsTM12072011.pdf

usefulness of a water supply to meet a beneficial water use, the comparison is done for two time periods in a given year: September 1 through May 31, and June 1 through August 31. Additionally, statute requires that the comparison be done to evaluate both the near term and long term balance. The only difference between the near-term and long-term analysis is that consumptive water demands for high capacity (greater than 50 gallons per minute) groundwater well pumping are replaced with the level of groundwater depletion associated with these uses over the representative period.

4.3.3.1 Near-Term Balance

The determination of the balance between current water supplies and uses in the near term focuses on a comparison of Basin Water Supplies and Current Uses over the representative period. The comparison will yield results which describe the amount, location, and timing of the surplus and deficit in water supply. An evaluation of the water supply surplus and deficit results will be conducted to determine the fully appropriated status of each basin, subbasin, or reach. Current Uses are determined by summing: 1) the rate of groundwater depletions; 2) consumptive water demands for surface water uses; 3) the net water determined to be necessary to deliver streamflows to meet consumptive demands of surface water; 4) streamflow available to meet instream flow appropriations at the time the appropriation was granted (accounting for all development in place at such time the appropriation was granted); 5) instream flow demands for hydropower operations; and 6) the proportionate amount of Basin Water Supplies necessary to meet demands downstream of a given basin, subbasin, or reach. Should the volume of deficits exceed the supplies then a preliminary determination of fully appropriated will be reached.

4.3.3.2 Long-Term Balance

The determination of the balance between current water supplies and uses in the long term focuses on the comparison of surplus and deficits of Basin Water Supplies and Total Use over the representative period. Total Use is determined by summing: 1) consumptive water demands for high capacity (greater than 50 gallons per minute) groundwater well pumping; 2) consumptive water demands for surface water uses; 3) the net water determined to be necessary to deliver streamflows to meet consumptive demands of surface water; 4) streamflow available to meet instream flow appropriations at the time the appropriation was granted (accounting for all development in place at such time the appropriation was granted); 5) instream flow demands for hydropower operations; and 6) the proportionate amount of Basin Water Supplies necessary to meet demands downstream of a given basin, subbasin, or reach. This analysis is refined to evaluate this balance over two portions of the year: September 1 through May 31, and June 1 through August 31. Should the volume of deficits exceed the supplies then a preliminary determination of fully appropriated will be reached.

4.3.4 Evaluation of Compliance with Compacts, Decrees, Agreements, and 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) of 457 NAC 24.001. 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.

For the areas of the state not currently designated as fully or overappropriated, only one basin is subject to an interstate compact, decree, or agreement, specifically, the Blue River Basin. The State of Nebraska is a signatory member of the Kansas – Nebraska Big Blue River Compact (Compact). The purposes of the Compact are to promote interstate comity, to achieve an equitable apportionment of the waters of the Big Blue River Basin, to encourage continuation of the active pollution-abatement programs in each of the two states, and to seek further reduction in pollution of the waters of the Big Blue River Basin. As long as Nebraska administers surface and groundwater in compliance with the Compact, decreased streamflow, in and of itself, will not cause Nebraska to be in noncompliance with the Compact.

4.4 Evaluating the Impacts of Predicted Future Development in a Basin

In addition to the Department's evaluation of current levels of development, the Department is required to assess how the preliminary conclusion would change if no additional legal constraints were imposed on future development of hydrologically connected water supplies. The results of the evaluation of future development will not be used on their own to reach a preliminary determination that a basin, subbasin, or reach is fully appropriated.

The Department is required by § 46-713 to project the impact of reasonable future development within a basin on the potential for a preliminary designation of fully appropriated. 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 development trends on the basin's future balance between water supplies and uses. The steps necessary to calculate the impacts of future development on the preliminary determination parallel those used to assess the balance between Basin Water Supplies and

Total Uses (described above in Section 4.3.3.2). The only difference is that the Department will utilize the best available science and data to determine an appropriate method for projecting future development over the next twenty-five years.