Simulated Stream Baseflow Changes in the Nebraska Platte Basin above U.S. Highway 183 due to Reduced Groundwater Irrigated Land after July 1, 1997

by

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Introduction

In October 2006, the Nebraska Department of Natural Resources and the Cooperative Hydrology Study (COHYST) entered into an agreement to estimate the effects of reduced pumpage on stream baseflows in the Platte River basin. This study looked at irrigated land developed prior to July 1, 1997. The analysis was for a 50-year period beginning with the irrigation season that started May 1, 1998. In this analysis, *stream baseflow* or *stream baseflow change* refer to direct movement of water between the aquifer and the stream, and does not include baseflow from outside the study area or to other changes to streamflow that may result from assumed reductions in irrigated land, such as changes in runoff. Simulations included no reduction in 1997 groundwater irrigated land, 20-percent reduction, 40-percent reduction, 60-percent reduction, 80-percent reduction, and 100-percent reduction. Surface-water irrigated land remained at 1997 levels in this analysis. No supplemental groundwater was simulated on surface-water irrigated land in any of the analyses in this report.

The reductions in irrigated land were investigated for two areas. The first area was the Hydrologically Connected Area for the Overappropriated Basin (HCA/OA) (fig. 1). The HCA/OA is an administrative determination by the Nebraska Department of Natural Resources and has consequences under Nebraska law. The second area was the entire COHYST study area, hereafter referred to as *everywhere*. Table 1 summarizes 1997 groundwater irrigated land in the COHYST area by county and table 2 summarizes it by Natural Resources District. The reduction in 1997 groundwater irrigated land was assumed to happen immediately at the beginning of the analysis. The reduction in irrigated land also was assumed to occur uniformly across the area of the analysis. Tables are placed after the text to avoid splitting up the text. Figures are placed at the end of the report and immediately follow the tables.

The analysis was to determine when and where changes in stream baseflow would occur. To address the where part of the analysis, the area was subdivided into stream reaches contributing to four sub-areas: Wyoming line to Kingsley Dam, Kingsley Dam to Tri-County Supply Canal diversion, Tri-County Supply Canal diversion to Lexington, and Lexington to U.S. Highway 183 (fig. 1). These are the same sub-areas considered in a recent analysis of estimated stream baseflow depletions due to new irrigated land developed after July 1, 1997 (Luckey and others, 2006). No analysis was done east of U.S. Highway 183 because the HCA/OA ends at U.S. Highway 183.

The analysis was limited to the streams in the Platte River system, including the North Platte and South Platte Rivers, and their baseflow tributaries. Baseflow tributaries have flow in them essentially year-round because of groundwater discharge to them. Tributaries were simulated in the models using the MODFLOW stream package to the upstream point at which they were flowing streams prior to large-scale groundwater development. However, some portions of the tributaries in the models may have been dry at the start of the simulations. The analysis extended beyond the surface-water divides of the Platte River system because changes in the groundwater system beyond the divide can still affect stream baseflows in the Platte River system.

The analysis assumed 1997 land-use conditions (Dappen and Tooze, 2001) and tillage practices to compute net pumpage (pumpage minus deep percolation of applied groundwater). To simulate reduced irrigated land after 1997, net pumpage was reduced by an amount equal to the assumed reduction in irrigated land. Net pumpage was computed with the CropSim soil-water balance model (Derrel Martin, University of Nebraska–Lincoln, unpublished) using the ETr_90_Avg_ET scenario (The Flatwater Group, 2004). The ETr_90_Avg_ET scenario averages daily reference crop evapotranspiration across the entire COHYST area for all meteorological stations. Net pumpage from this scenario was used when calibrating the groundwater flow models described in the next section. Throughout this report, the term pumpage means net pumpage, even if that is not explicitly stated.

In this report, *dryland* refers to the following land classifications from Dappen and Tooze (2001): summer fallow, dryland corn, dryland soybeans, dryland sorghum, dryland dry edible beans, dryland alfalfa, dryland small grains, and dryland sunflowers. *Irrigated land* refers to the following land classifications from Dappen and Tooze (2001): irrigated corn, irrigated soybeans, irrigated sorghum, irrigated dry edible beans, irrigated alfalfa, irrigated small grains, irrigated sunflowers, irrigated sugar beets, and irrigated potatoes.

Groundwater Models

Groundwater flow models covering three overlapping areas were used in this analysis (fig. 1). The Western Model Unit begins 6 miles west of the Nebraska-Wyoming Stateline and extends east to Kingsley Dam in central Keith County. This model was used to estimate effects for Wyoming line to Kingsley Dam (Reach A). The Central Model Unit covers an area extending from eastern Garden County to central Dawson County. This model was used to estimate effects for Kingsley Dam to Tri-County Supply Canal diversion (Reach B) and Tri-County Supply Canal diversion to Lexington (Reach C). The Eastern Model Unit covers an area extending from western Dawson County to eastern Polk County. This model was used to estimate effects for Lexington to U.S. Highway 183 (Reach D). All three models had cell sizes of 160 acres. The western model had a single layer. The central and eastern models had six and five layers respectively, although fewer layers actually exist in most areas. The western model was documented by Luckey and Cannia (2006). Model documentations for the other two models used in this analysis are being finalized and are planned to be placed on the COHYST Internet site in the future.

Prior to this study, Duane Woodward of Central Platte Natural Resources District discovered that an incorrect CropSim pumpage data set had been used to calibrate the western model. This affected only the groundwater development period model (1950-98) and only that part of the calibration that used CropSim pumpage. The western model was recalibrated using the correct CropSim pumpage, with recharge on irrigated land adjusted to achieve calibration. Recharge on irrigated land was increased by 0.10 inches per year for all soils from the values reported by Luckey and Cannia (2006, p. 45) to achieve calibration. All other model inputs remained the same. The recalibrated western model was used in this analysis.

The groundwater flow models assume different rates of recharge due to precipitation falling on rangeland, dryland, and irrigated land. These rates were determined during model calibration. The recharge used in the simulations without any reduction in irrigated land was an average of the last three years of the calibrated models. The simulated reductions in irrigated land assumed in this analysis were assumed to result in equivalent increases in dryland. The recharge in each simulation was adjusted to account for irrigated land being converted to dryland. The difference between simulated recharge on irrigated land and on dryland is substantial, ranging from less than 3 inches per year to more than 6 inches per year, depending on the area. This difference in recharge substantially reduced the stream baseflow gains that otherwise would have occurred solely due to reduced pumpage for groundwater irrigated land.

Simulated water levels on May 1, 1998, were the starting water levels in the models used in this analysis. The models simulated two stress periods per year, an irrigation season (May through September) and a non-irrigation season (October through April). Despite the name, some irrigation on small grains and alfalfa was simulated during the non-irrigation season. Pumpage was held constant within a stress period but was varied between stress periods. Pumpage was held constant or was varied on a year-by-year basis as described in the Meteorological Data section. Simulation time steps were approximately monthly, with the irrigation season simulated in 5 time steps and the non-irrigation season simulated in 7 time steps. The models simulated 50 years, from May 1, 1998, to May 1, 2048.

Meteorological Data

The analysis was done using two different meteorological data sets, average conditions and variable conditions. Both conditions were based on 48 years of meteorological data beginning May 1, 1950, from 39 meteorological stations scattered throughout the area. For each 1-mile area (2-by-2 model cells), the three nearest meteorological stations were selected and the average values for precipitation, crop evapotranspiration, and net irrigation requirement were computed using an inverse distance weighted interpolation. The 39 stations maintained the natural gradients in precipitation that exist across the COHYST area.

The variable meteorological conditions used the 48 years of meteorological data beginning May 1, 1950, and reused the first two years at the end to get 50 years of precipitation and other data. Crop evapotranspiration and net irrigation requirement were calculated for 50 years using the variable meteorological data.

The analysis started with 1997 net pumpage for average meteorological conditions because 1997 precipitation was close to average. Overall, 1997 was slightly dryer than the 1895-1998 average (-0.47 inches), with the range of 1997 deviation from average being +0.76 inches (Climate Division 1) to -1.98 inches (Climate Division 6). The 1997 net pumpage was then adjusted so that annual pumpage for each model unit for average meteorological conditions was equal to average annual pumpage for variable meteorological conditions. The adjustment factor was 1.191 for the Western Model Unit, 0.887 for the Central Model Unit, and 0.885 for the Eastern Model Unit.

The results using the two different meteorological data sets were compared to determine if average meteorological conditions adequately represented long-term effects of reduced pumpage on stream baseflow. If average conditions could be used, the analysis would be simplified and the results would have less variability. Both meteorological data sets were used to simulate no change in irrigated land after 1997 and reduced irrigated land after 1997 for one area (Wyoming line to Kingsley Dam). The meteorological data set that was selected for use in subsequent analyses is described in the Selected Meteorological Data section.

The meteorological data sets may not adequately represent actual future meteorological conditions. Some consideration was given to using an artificial meteorological data set with more severe droughts and longer wetter periods than were present in the 1950-97 data. This idea was discarded because it would be difficult to determine an appropriately representative data set for these more unusual conditions.

Pumping Effect

In this report, the *Pumping Effect* (PE) refers to potential changes in simulated stream baseflow after 1997 without any changes in land use after 1997. The PE assumes no reduction in groundwater irrigated land after 1997. The PE is sometimes referred to as the “lag effect,” but that term is not used here because lag effect seems to mean different things to different people. Changes in simulated stream baseflow can occur after 1997 without any changes in land use because pumpage and recharge distant from streams take a long time to affect the streams. This analysis used actual estimated net pumpage from 1950 through 1997, and then held annual pumpage constant after 1997 in the average meteorological conditions analysis. In the variable meteorological conditions analysis, 1997 land use was held constant, so the long-term average annual pumpage was constant after 1997.

The PE analysis used temporally varying recharge for 1950 through 1997 and constant recharge after 1997. In a general sense, total simulated recharge increased between 1950 and 1997. There was some expansion in surface-water irrigation after 1950 and this expansion increased simulated recharge. Some surface-water irrigation systems increased delivery efficiency between 1950 and 1997, which resulted in decreased simulated recharge. A considerable amount of land was converted from dryland to irrigated land between 1950 and 1997, which resulted in increased simulated recharge. This increased recharge between 1950 and 1997 tended to increase stream baseflow or to reduce the depletions to stream baseflow after 1997 even though simulated recharge was constant after 1997. The increased recharge between 1950 and 1997 partially offset the effect of increased pumpage between 1950 and 1997.

The PE can result in either decreased simulated stream baseflow after 1997 or increased simulated stream baseflow after 1997, depending on the relative magnitudes of changes in pumpage and recharge. The rate of change of the PE diminishes over time, and given enough time, the groundwater flow system will reach a new equilibrium. The PE for each of the four analysis areas is shown in figure 2. The PE for average meteorological conditions is shown as lower red lines and the PE for variable meteorological conditions is shown as lower black lines. The PE curves are essentially flat for Wyoming line to Tri-County Supply Canal diversion, indicating little change in stream baseflow with continued pumping at 1997 levels. The PE curves rise for Tri-County Supply Canal diversion to U.S. Highway 183, indicating a gradual increase in stream baseflow with continued pumping at 1997 levels.

No Pumping Effect

In this report, the *No Pumping Effect* (NPE) refers to potential changes in simulated stream baseflow after 1997 with elimination of pumpage on groundwater irrigated land after 1997. The NPE is sometimes referred to as the "residual effect," but that term is not used here because residual effect seems to mean different things to different people. The NPE considers 100 percent reduction in groundwater irrigated land after 1997 over two areas, the HCA/OA and the entire COHYST area. This analysis used actual estimated increased pumpage from 1950 through 1997, and then set pumpage on groundwater irrigated land to zero for the appropriate area after 1997. The simulated recharge increased from 1950 through 1997 because dryland was converted to irrigated land. The simulated recharge decreased abruptly after 1997 because irrigated land was converted to dryland. The NPE does not depend on meteorological data after 1997 because, in the models, only pumpage varies as a result of meteorological conditions. The NPE for the HCA/OA is shown in figure 2 as the upper blue line and the NPE for the entire COHYST area is shown in figure 2 as the upper black line. The NPE curves for all four reaches show a gradual increase in stream baseflow after 1998, with the rate of change decreasing over time. However, even after 50 years without pumping, the system has not reached equilibrium.

The differences between the NPE curves for the HCA/OA and the entire COHYST area increase going downstream when the differences are viewed relative to the total stream baseflow. For Wyoming line to Kingsley Dam, the difference is 1 percent of the 1998 stream baseflow. For Kingsley Dam to Tri-County Supply Canal diversion, the difference is 9 percent of the 1998 stream baseflow. For Tri-County Supply Canal diversion to Lexington, the difference is 13 percent of the 1998 stream baseflow. For Lexington to U.S. Highway 183, the difference is 32 percent of the 1998 stream baseflow. This indicates that effects from pumping outside the HCA/OA on stream baseflow increase going downstream.

Summary of Pumping Effect and No Pumping Effect

Table 3 shows simulated stream baseflow for the PE and NPE. Differences between the PE and NPE in the text may be slightly different from the differences between the numbers in table 3 because the numbers in table 3 are rounded, and the differences reported in the text were computed before the numbers were rounded. Some dates in table 3 were chosen for convenience to correspond to dates consistent with the Platte River Recovery Implementation Program, of which Nebraska is a participant.

For Wyoming line to Kingsley Dam, simulated stream baseflow in the Platte basin due to the PE assuming average meteorological conditions was 834 ft^3/s on October 1, 2007, and was 849 ft^3/s on May 1, 2008. This compares to simulated stream baseflow in the calibrated model of 837 ft^3/s on October 1, 1997, and 848 ft^3/s on May 1, 1998. Stream baseflow due to PE assuming variable meteorological conditions was 831 ft^3/s on October 1, 2007, and was 848 ft^3/s on May 1, 2008. Stream baseflow due to NPE in the HCA/OA was 867 ft^3/s on October 1, 2007, and was 867 ft^3/s on May 1, 2008. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 33 ft^3/s on October 1, 2007, and was 19 ft^3/s on May 1, 2008. Stream baseflow due to PE assuming average meteorological conditions was 834 ft^3/s on October 1, 2013, and was 849 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming variable meteorological conditions was 837 ft^3/s on October 1, 2013, and was 850 ft^3/s on May 1, 2014. Stream baseflow due to NPE in the HCA/OA was 871 ft^3/s on October 1, 2013, and was 871 ft^3/s on May 1, 2014. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 36 ft^3/s on October 1, 2013, and was 22 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming average meteorological conditions was 835 ft^3/s on October 1, 2047, and was 850 ft^3/s on May 1, 2048. Stream baseflow due to PE assuming variable meteorological conditions was 842 ft^3/s on October 1, 2047, and was 854 ft^3/s on May 1, 2048. Stream baseflow due to NPE in the HCA/OA was 879 ft^3/s on October 1, 2047, and was 879 ft^3/s on May 1, 2048. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 44 ft^3/s on October 1, 2047, and was 30 ft^3/s on May 1, 2048. The difference between simulated stream baseflow on May 1, 2048, for the NPE in the HCA/OA versus NPE everywhere was 6 ft^3/s.

For Kingsley Dam to Tri-County Supply Canal diversion, simulated stream baseflow in the Platte basin due to PE assuming average meteorological conditions was 351 ft^3/s on October 1, 2007, and was 402 ft^3/s on May 1, 2008. This compares to simulated stream baseflow in the calibrated model of 369 ft^3/s on October 1, 1997, and 416 ft^3/s on May 1, 1998. Stream baseflow due to PE assuming variable meteorological conditions was 344 ft^3/s on October 1, 2007, and was 399 ft^3/s on May 1, 2008. Stream baseflow due to NPE in the HCA/OA was 438 ft^3/s on October 1, 2007, and was 439 ft^3/s on May 1, 2008. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 87 ft^3/s on October 1, 2007, and was 37 ft^3/s on May 1, 2008. Stream baseflow due to PE assuming average meteorological conditions was 351 ft^3/s on October 1, 2013, and was 401 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming variable meteorological conditions was 343 ft^3/s on October 1, 2013, and was 394 ft^3/s on May 1, 2014. Stream baseflow due to NPE in the HCA/OA was 443 ft^3/s on October 1, 2013, and was 443 ft^3/s on May 1, 2014. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 91 ft^3/s on October 1, 2013, and was 41 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming average meteorological conditions was 351 ft^3/s on October 1, 2047, and was 402 ft^3/s on May 1, 2048. Stream baseflow due to PE assuming variable meteorological conditions was 361 ft^3/s on October 1, 2047, and was 401 ft^3/s on May 1, 2048. Stream baseflow due to NPE in the HCA/OA was 452 ft^3/s on October 1, 2047, and was 452 ft^3/s on May 1, 2048. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 99 ft^3/s on October 1, 2047, and was 48 ft^3/s on May 1, 2048. The difference between simulated stream baseflow on May 1, 2048, for the NPE in the HCA/OA versus NPE everywhere was 35 ft^3/s. Note that by subtracting the number in table

3, you get 34 ft^3/s. However, the numbers in table 3 are rounded, and the differences reported throughout this report were computed before the numbers were rounded.

For Tri-County Supply Canal diversion to Lexington, simulated stream baseflow in the Platte basin due to PE assuming average meteorological conditions was 262 ft^3/s on October 1, 2007, and was 301 ft^3/s on May 1, 2008. This compares to simulated stream baseflow in the calibrated model of 281 ft^3/s on October 1, 1997, and 317 ft^3/s on May 1, 1998. Stream baseflow due to PE assuming variable meteorological conditions was 265 ft^3/s on October 1, 2007, and was 307 ft^3/s on May 1, 2008. Stream baseflow due to NPE in the HCA/OA was 318 ft^3/s on October 1, 2007, and was 319 ft^3/s on May 1, 2008. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 56 ft^3/s on October 1, 2007, and was 18 ft^3/s on May 1, 2008. Stream baseflow due to PE assuming average meteorological conditions was 263 ft^3/s on October 1, 2013, and was 303 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming variable meteorological conditions was 287 ft^3/s on October 1, 2013, and was 316 ft^3/s on May 1, 2014. Stream baseflow due to NPE in the HCA/OA was 322 ft^3/s on October 1, 2013, and was 323 ft^3/s on May 1, 2014. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 59 ft^3/s on October 1, 2013, and was 21 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming average meteorological conditions was 267 ft^3/s on October 1, 2047, and was 307 ft^3/s on May 1, 2048. Stream baseflow due to PE assuming variable meteorological conditions was 289 ft^3/s on October 1, 2047, and was 323 ft^3/s on May 1, 2048. Stream baseflow due to NPE in the HCA/OA was 331 ft^3/s on October 1, 2047, and was 332 ft^3/s on May 1, 2048. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 64 ft^3/s on October 1, 2047, and was 26 ft^3/s on May 1, 2048. The difference between simulated stream baseflow on May 1, 2048, for the NPE in the HCA/OA versus NPE everywhere was 39 ft^3/s.

For Lexington to U.S. Highway 183, simulated stream baseflow in the Platte basin due to PE assuming average meteorological conditions was 48 ft^3/s on October 1, 2007, and was 57 ft^3/s on May 1, 2008. This compares to simulated stream baseflow in the calibrated model of 44 ft^3/s on October 1, 1997, and 53 ft^3/s on May 1, 1998. Stream baseflow due to PE assuming variable meteorological conditions was 46 ft^3/s on October 1, 2007, and was 55 ft^3/s on May 1, 2008. Stream baseflow due to NPE in the HCA/OA was 67 ft^3/s on October 1, 2007, and was 68 ft^3/s on May 1, 2008. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 20 ft^3/s on October 1, 2007, and was 11 ft^3/s on May 1, 2008. Stream baseflow due to PE assuming average meteorological conditions was 50 ft^3/s on October 1, 2013, and was 59 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming variable meteorological conditions was 54 ft^3/s on October 1, 2013, and was 60 ft^3/s on May 1, 2014. Stream baseflow due to NPE in the HCA/OA was 72 ft^3/s on October 1, 2013, and was 73 ft^3/s on May 1, 2014. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 22 ft^3/s on October 1, 2013, and was 14 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming average meteorological conditions was 59 ft^3/s on October 1, 2047, and was 68 ft^3/s on May 1, 2048. Stream baseflow due to PE assuming variable meteorological conditions was 66 ft^3/s on October 1, 2047, and was 73 ft^3/s on May 1, 2048. Stream baseflow due to NPE in the HCA/OA was 86 ft^3/s on October 1, 2047, and was 86 ft^3/s on May 1, 2048. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was

27 ft^3/s on October 1, 2047, and was 18 ft^3/s on May 1, 2048. The difference between simulated stream baseflow on May 1, 2048, for the NPE in the HCA/OA versus NPE everywhere was 8 ft^3/s.

For Wyoming line to U.S. Highway 183, simulated stream baseflow in the Platte basin due to PE assuming average meteorological conditions was 1,495 ft^3/s on October 1, 2007, and was 1,608 ft^3/s on May 1, 2008. Stream baseflow due to PE assuming variable meteorological conditions was 1,486 ft^3/s on October 1, 2007, and was 1,608 ft^3/s on May 1, 2008. Stream baseflow due to NPE in the HCA/OA was 1,690 ft^3/s on October 1, 2007, and was 1,693 ft^3/s on May 1, 2008. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 195 ft^3/s on October 1, 2007, and was 85 ft^3/s on May 1, 2008. Stream baseflow due to PE assuming average meteorological conditions was 1,499 ft^3/s on October 1, 2013, and was 1,612 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming variable meteorological conditions was 1,538 ft^3/s on October 1, 2013, and was 1,629 ft^3/s on May 1, 2014. Stream baseflow due to NPE in the HCA/OA was 1,708 ft^3/s on October 1, 2013, and was 1,710 ft^3/s on May 1, 2014. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 209 ft^3/s on October 1, 2013, and was 98 ft^3/s on May 1, 2014. Stream baseflow due to PE assuming average meteorological conditions was 1,513 ft^3/s on October 1, 2047, and was 1,626 ft^3/s on May 1, 2048. Stream baseflow due to PE assuming variable meteorological conditions was 1,558 ft^3/s on October 1, 2047, and was 1,651 ft^3/s on May 1, 2048. Stream baseflow due to NPE in the HCA/OA was 1,748 ft^3/s on October 1, 2047, and was 1,749 ft^3/s on May 1, 2048. The difference between PE assuming average meteorological conditions and the NPE in the HCA/OA was 235 ft^3/s on October 1, 2047, and was 123 ft^3/s on May 1, 2048. The difference between simulated stream baseflow on May 1, 2048, for the NPE in the HCA/OA versus NPE everywhere was 88 ft^3/s.

Selected Meteorological Data

Figure 2 shows the differences between using average and variable meteorological data with constant 1997 land use. When 1950-97 meteorological data was used to calculate 1998 to 2048 pumpage, there was some year-to-year variability in simulated stream baseflow for the PE, as shown by the lower black line. However, the variations are small compared to total stream baseflow. Using average meteorological data, as shown by the lower red line, removes the year-to-year variability in the PE. Either meteorological data set produces essentially the same results, when the 50-year period is viewed as a whole. The variable meteorological data set produces smaller stream baseflows in the middle of the analysis compared to the average meteorological data set. This is because the drought of the 1970s caused simulated pumpage with variable meteorological data to be larger than simulated pumpage with average meteorological data. The variable meteorological data set produces larger stream baseflows in the last decade of the analysis compared to the average meteorological data set. This is because the period 1990-97 was unusually wet, so simulated pumpage for this period with variable meteorological data was smaller than simulated pumpage with average meteorological data.

Figure 2 was not sufficient to determine whether average or variable meteorological data should be used for subsequent analysis, so both sets of data were used to look at the effects of reducing groundwater irrigated land after 1997 in the HCA/OA for Wyoming line to Kingsley Dam. Figure 3 shows stream baseflows for Wyoming line to Kingsley Dam using variable meteorological data (upper graphs) and average meteorological data (lower graphs).

The average meteorological data set was chosen for further analysis because the differences between the curves representing various levels of reduced groundwater irrigated land are more apparent using average meteorological data (lower graphs). It is the differences between the curves that are important when considering the effects of reductions in groundwater irrigated land on stream baseflow.

Effects of Reduced Groundwater Irrigated Land in the Hydrologically Connected Area of the Overappropriated Basin

This analysis looked at the effects of reducing groundwater irrigated land after 1997 only in the HCA/OA (fig. 1). The purpose of this analysis was to help water resources managers in the area understand what would be required to revert over-appropriated areas to fully appropriated areas. Groundwater irrigated lands outside the HCA/OA were held at 1997 levels in this analysis. The analysis considered the following reductions in 1997 groundwater irrigated land in the HCA/OA: 20-percent, 40-percent, 60-percent, 80-percent, and 100-percent. The figures associated with this analysis also show no reduction in irrigated land in the HCA/OA for comparison purposes.

Table 4 shows simulated stream baseflow for reduced groundwater irrigated land in the HCA/OA. Differences between the various reductions in the text may be slightly different from the differences between the numbers in table 4 because the numbers in table 4 are rounded, and the differences reported in the text were computed before the numbers were rounded. Some dates in table 4 were chosen for convenience to correspond to dates consistent with the Platte River Recovery Implementation Program, of which Nebraska is a participant.

The effects of these reductions on stream baseflows are shown in figure 4. For Wyoming line to Kingsley Dam, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 849 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 3 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 7 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 11 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 15 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 19 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 849 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 4 ft^3/s from the no reduction scenario. With a 40-

percent reduction, stream baseflow on the same date increased by 8 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 13 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 18 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 22 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 850 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 5 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 10 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 16 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 24 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 30 ft^3/s from the no reduction scenario.

For Kingsley Dam to Tri-County Supply Canal diversion, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 402 ft^3/s (fig. 4). With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 8 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 15 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 22 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 30 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 37 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 401 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 9 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 17 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 25 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 33 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 42 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 402 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 10 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 20 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 30 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 40 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 50 ft^3/s from the no reduction scenario.

For Tri-County Supply Canal diversion to Lexington, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 301 ft^3/s (fig. 4). With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 4 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 7 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 11 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 14 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 18 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 303 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 4 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 8 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 12 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 16 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 21 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 307 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 5 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 10 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 15 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 21 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 25 ft^3/s from the no reduction scenario.

For Lexington to U.S. Highway 183, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 57 ft^3/s (fig. 4). With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 2 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 4 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 7 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 9 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 11 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 59 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 3 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 5 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 8 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 11 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 14 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 68 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 4 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 7 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 11 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 15 ft^3/s from the no reduction scenario. With a 100-

percent reduction, stream baseflow on the same date increased by 18 ft^3/s from the no reduction scenario.

For Wyoming line to U.S. Highway 183, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 1,608 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 17 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 34 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 50 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 68 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 85 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 1,612 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 19 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 39 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 58 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 79 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 98 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 1,626 ft^3/s. With a 20-percent reduction in irrigated land in the HCA/OA after 1997, stream baseflow on the same date increased by 24 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 48 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 72 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 99 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 123 ft^3/s from the no reduction scenario.

Effects of Reduced Groundwater Irrigated Land Everywhere

This analysis looked at the effects of reducing groundwater irrigated land after 1997 everywhere in the study area (fig. 1). The analysis considered a 20-percent reduction in 1997 groundwater irrigated land everywhere, a 40-percent reduction, a 60-percent reduction, an 80-percent reduction, and a 100-percent reduction. The figure associated with this analysis also shows no reduction in irrigated land for comparison purposes.

Table 5 shows simulated stream baseflow for reduced groundwater irrigated land everywhere. Differences between the various reductions in the text may be slightly different from the numbers in table 5 because the numbers in table 5 are rounded, and the differences reported in the text were computed before the numbers were rounded. Some dates in table 5 were chosen for convenience to correspond to dates consistent with the Platte River Recovery Implementation Program, of which Nebraska is a participant.

The results of this analysis are shown in figure 5. For Wyoming line to Kingsley Dam, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 849 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 4 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 7 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 11 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 15 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 19 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 849 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 4 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 9 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 13 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 18 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 23 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 850 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 6 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 12 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 19 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 27 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 35 ft^3/s from the no reduction scenario.

For Kingsley Dam to Tri-County Supply Canal diversion, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 402 ft^3/s (fig. 5). With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 9 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 18 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 26 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 34 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 43 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 401 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 11 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 22 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 32 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 42 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 53 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 402 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 17 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 34 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 50 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 67 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 84 ft^3/s from the no reduction scenario.

For Tri-County Supply Canal diversion to Lexington, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 301 ft^3/s (fig. 5). With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 5 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 11 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 16 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 21 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 26 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 303 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 7 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 13 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 20 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 27 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 34 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 307 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 12 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 24 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 36 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 50 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 64 ft^3/s from the no reduction scenario.

For Lexington to U.S. Highway 183, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 57 ft^3/s (fig. 5). With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 3 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 6 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 8 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 11 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 14 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 59 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 3 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 7 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 10 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 14 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 18 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 68 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 5 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 10 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 15 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 21 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 26 ft^3/s from the no reduction scenario.

For Wyoming line to U.S. Highway 183, simulated stream baseflow in the Platte basin on May 1, 2008, without any reduction of groundwater irrigated land after 1997, was 1,608 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 20 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 41 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 61 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 81 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 103 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2014, without any reduction of irrigated land after 1997 was 1,612 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 25 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 50 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 75 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 101 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 128 ft^3/s from the no reduction scenario. Simulated stream baseflow on May 1, 2048, without any reduction of irrigated land after 1997 was 1,626 ft^3/s. With a 20-percent reduction in irrigated land everywhere after 1997, stream baseflow on the same date increased by 39 ft^3/s from the no reduction scenario. With a 40-percent reduction, stream baseflow on the same date increased by 80 ft^3/s from the no reduction scenario. With a 60-percent reduction, stream baseflow on the same date increased by 122 ft^3/s from the no reduction scenario. With an 80-percent reduction, stream baseflow on the same date increased by 165 ft^3/s from the no reduction scenario. With a 100-percent reduction, stream baseflow on the same date increased by 210 ft^3/s from the no reduction scenario.

Differences between Reduced Groundwater Irrigated Land in the Hydrologically Connected Area of the Overappropriated Basin and Reduced Groundwater Irrigated Land Everywhere

The differences in stream baseflow between reducing groundwater irrigated land after 1997 only in the HCA/OA versus reducing groundwater irrigated land everywhere is shown in table 6. As expected, the differences are small in early times and with small reductions in irrigated land. The differences become larger for later times and larger reductions. The differences between the numbers in tables 4 and 5 may be slightly different from the numbers in table 6 because the numbers in tables 4 and 5 are rounded, and the differences reported in table 6 were computed before the numbers were rounded.

For Wyoming line to Kingsley Dam, the difference in simulated stream baseflow in the Platte basin on May 1, 2008, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 0 ft^3/s. The difference with a 40-percent reduction on the same date was 0 ft^3/s; the difference with a 60-percent reduction was 0 ft^3/s; the difference with an 80-percent reduction was 0 ft^3/s; and the difference with a 100-percent reduction was 0 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2014, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 0 ft^3/s. The difference with a 40-percent reduction on the same date was 1 ft^3/s; the difference with a 60-percent reduction was 1 ft^3/s; the difference with an 80-percent reduction was 0 ft^3/s; and the difference with a 100-percent reduction was 1 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2048, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 1 ft^3/s. The difference with a 40-percent reduction on the same date was 2 ft^3/s; the difference with a 60-percent reduction was 3 ft^3/s; the difference with an 80-percent reduction was 3 ft^3/s; and the difference with a 100-percent reduction was 6 ft^3/s. The values with 80-percent reduction look a little strange, and may partially represent noise in the solutions rather than real differences in effects.

For Kingsley Dam to Tri-County Supply Canal, the difference in simulated stream baseflow in the Platte basin on May 1, 2008, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 1 ft^3/s. The difference with a 40-percent reduction on the same date was 2 ft^3/s; the difference with a 60-percent reduction was 3 ft^3/s; the difference with an 80-percent reduction was 5 ft^3/s; and the difference with a 100-percent reduction was 6 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2014, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 2 ft^3/s. The difference with a 40-percent reduction on the same date was 4 ft^3/s; the difference with a 60-percent reduction was 6 ft^3/s; the difference with an 80-percent reduction was 9 ft^3/s; and the difference with a 100-percent reduction was 11 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2048, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 7 ft^3/s. The difference with a 40-percent reduction on the same date was 14 ft^3/s; the difference with a 60-percent reduction was 21 ft^3/s; the difference with an

80-percent reduction was 27 ft^3/s; and the difference with a 100-percent reduction was 35 ft^3/s.

For Tri-County Supply Canal to Lexington, the difference in simulated stream baseflow in the Platte basin on May 1, 2008, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 1 ft^3/s. The difference with a 40-percent reduction on the same date was 3 ft^3/s; the difference with a 60-percent reduction was 5 ft^3/s; the difference with an 80-percent reduction was 6 ft^3/s; and the difference with a 100-percent reduction was 8 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2014, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 2 ft^3/s. The difference with a 40-percent reduction on the same date was 5 ft^3/s; the difference with a 60-percent reduction was 8 ft^3/s; the difference with an 80-percent reduction was 10 ft^3/s; and the difference with a 100-percent reduction was 14 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2048, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 6 ft^3/s. The difference with a 40-percent reduction on the same date was 13 ft^3/s; the difference with a 60-percent reduction was 21 ft^3/s; the difference with an 80-percent reduction was 30 ft^3/s; and the difference with a 100-percent reduction was 39 ft^3/s.

For Lexington to U.S. Highway 183, the difference in simulated stream baseflow in the Platte basin on May 1, 2008, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 1 ft^3/s. The difference with a 40-percent reduction on the same date was 1 ft^3/s; the difference with a 60-percent reduction was 2 ft^3/s; the difference with an 80-percent reduction was 2 ft^3/s; and the difference with a 100-percent reduction was 3 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2014, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 1 ft^3/s. The difference with a 40-percent reduction on the same date was 1 ft^3/s; the difference with a 60-percent reduction was 2 ft^3/s; the difference with an 80-percent reduction was 3 ft^3/s; and the difference with a 100-percent reduction was 4 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2048, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 1 ft^3/s. The difference with a 40-percent reduction on the same date was 3 ft^3/s; the difference with a 60-percent reduction was 4 ft^3/s; the difference with an 80-percent reduction was 6 ft^3/s; and the difference with a 100-percent reduction was 8 ft^3/s.

For Wyoming line to U.S. Highway 183, the difference in simulated stream baseflow in the Platte basin on May 1, 2008, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 3 ft^3/s. The difference with a 40-percent reduction on the same date was 7 ft^3/s; the difference with a 60-percent reduction was 10 ft^3/s; the difference with an 80-percent reduction was 13 ft^3/s; and the difference with a 100-percent reduction was 18 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2014, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 6 ft^3/s. The difference with a 40-percent reduction on the same date was 11 ft^3/s; the difference with a 60-percent reduction was 17 ft^3/s; the difference with an 80-percent reduction was 23 ft^3/s; and the difference with a 100-percent reduction was 30 ft^3/s. The difference in simulated stream baseflow in the Platte basin on May 1, 2048, between a 20-percent reduction in groundwater irrigated land everywhere after 1997 and a 20-percent reduction only in the HCA/OA was 16 ft^3/s. The difference with a 40-percent reduction on the same date was 32 ft^3/s; the difference with a 60-percent reduction was 50 ft^3/s; the difference with an 80-percent reduction was 66 ft^3/s; and the difference with a 100-percent reduction was 87 ft^3/s.

Differences in Water Budgets with Reduced Groundwater Irrigated Land

Table 7 shows the differences between water budgets for the PE and NPE by model unit (fig. 1). The budgets had to be done by model unit rather than by stream reach because the budget components, other than streamflow, are not restricted to a particular stream reach. The NPE is shown for both the HCA/OA and the entire COHYST area. The differences in water budgets were averaged by decade to show general trends in the differences. All budget components are in units of cubic feet per second to make it easier to compare them to streamflow. The table shows reduced net stress, which is reduced pumpage on groundwater irrigated land minus reduced recharge due to conversion of irrigated land to dryland. Reduced net stress is the net effect on the aquifer of converting groundwater irrigated land to dryland. The differences between the water budgets show what happens to the reduced net stress on the aquifer in the NPE. Figure 6 shows the differences between water budgets for the PE and NPE graphically for the HCA/OA by model unit. Increased flow to lakes that intercept the water table was a small component of the water budget and was ignored in table 6 and figure 7.

For the first decade of the analysis for the Western Model Unit, pumpage in the HCA/OA was decreased in the NPE by 173 ft^3/s. However, conversion of groundwater irrigated land to dryland also decreased recharge by 61 ft^3/s, so the net stress on the aquifer was only decreased by 112 ft^3/s. Of the decreased net stress, 38 ft^3/s or 34 percent went to increased streamflow, 70 ft^3/s or 62 percent went to increased groundwater storage, and 4 ft^3/s or 4 percent went to increased evapotranspiration. For the third decade of the analysis, pumpage in the HCA/OA was decreased by 167 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 60 ft^3/s, so the net stress on the aquifer was only decreased by 107 ft^3/s. Differences in pumpage and recharge got smaller with time because some model cells go dry in the PE simulations. Of the decreased net stress, 63 ft^3/s or 59 percent went to increased streamflow, 38 ft^3/s or 36 percent went to increased groundwater storage, and 6 ft^3/s or 6 percent went to increased evapotranspiration. For the fifth decade of the analysis, pumpage in the HCA/OA was decreased by 162 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 57 ft^3/s, so the net stress on the aquifer was only decreased by 105 ft^3/s. Of the decreased net stress, 71 ft^3/s or 68 percent went to increased streamflow, 27 ft^3/s or 26 percent went to increased groundwater storage, and 8 ft^3/s or 8 percent went to increased evapotranspiration. Note that the percentages do not always sum to 100 because of rounding and ignoring increased flow to lakes.

For the first decade of the analysis for the Western Model Unit, pumpage in the entire COHYST area was decreased in the NPE by 448 ft^3/s. However, conversion of groundwater irrigated land to dryland also decreased recharge by 145 ft^3/s, so the net stress on the aquifer was only decreased by 303 ft^3/s. Of the decreased net stress, 38 ft^3/s or 13 percent went to increased streamflow, 245 ft^3/s or 81 percent went to increased groundwater storage, and 20 ft^3/s or 7 percent went to increased evapotranspiration. For the third decade of the analysis, pumpage in the entire COHYST area was decreased by 441 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 142 ft^3/s, so the net stress on the aquifer was only decreased by 299 ft^3/s. Of the decreased net stress, 69 ft^3/s or 23 percent went to increased streamflow, 182 ft^3/s or 61 percent went to increased groundwater storage, and 48 ft^3/s or 16 percent went to increased evapotranspiration. For the fifth decade of the analysis, pumpage in the entire COHYST area was decreased by 435 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 140 ft^3/s, so the net stress on the aquifer was only decreased by 295 ft^3/s. Of the decreased net stress, 81 ft^3/s or 27 percent went to increased streamflow, 152 ft^3/s or 52 percent went to increased groundwater storage, and 61 ft^3/s or 21 percent went to increased evapotranspiration.

For the first decade of the analysis for the Central Model Unit, pumpage in the HCA/OA was decreased in the NPE by 232 ft^3/s. However, conversion of groundwater irrigated land to dryland also decreased recharge by 60 ft^3/s, so the net stress on the aquifer was only decreased by 172 ft^3/s. Of the decreased net stress, 83 ft^3/s or 48 percent went to increased streamflow, 71 ft^3/s or 41 percent went to increased groundwater storage, and 18 ft^3/s or 10 percent went to increased evapotranspiration. For the third decade of the analysis, pumpage in the HCA/OA was decreased by 233 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 60 ft^3/s, so the net stress on the aquifer was only decreased by 173 ft^3/s. Of the decreased net stress, 114 ft^3/s or 66 percent went to increased streamflow, 34 ft^3/s or 20 percent went to increased groundwater storage, and 24 ft^3/s or 14 percent went to increased evapotranspiration. For the fifth decade of the analysis, pumpage in the HCA/OA was decreased by 234 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 62 ft^3/s, so the net stress on the aquifer was only decreased by 172 ft^3/s. Of the decreased net stress, 121 ft^3/s or 70 percent went to increased streamflow, 22 ft^3/s or 13 percent went to increased groundwater storage, and 25 ft^3/s or 15 percent went to increased evapotranspiration.

For the first decade of the analysis for the Central Model Unit, pumpage in the entire COHYST area was decreased in the NPE by 983 ft^3/s. However, conversion of groundwater irrigated land to dryland also decreased recharge by 221 ft^3/s, so the net stress on the aquifer was only decreased by 762 ft^3/s. Of the decreased net stress, 110 ft^3/s or 14 percent went to increased streamflow, 597 ft^3/s or 78 percent went to increased groundwater storage, and 49 ft^3/s or 6 percent went to increased evapotranspiration. For the third decade of the analysis, pumpage in the entire COHYST area was decreased by 983 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 226 ft^3/s, so the net stress on the aquifer was only decreased by 757 ft^3/s. Of the decreased net stress, 227 ft^3/s or 30 percent went to increased streamflow, 436 ft^3/s or 58 percent went to increased groundwater storage, and 81 ft^3/s or 11 percent went to increased evapotranspiration. For the fifth decade of the analysis, pumpage in the entire COHYST area was decreased by 983 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 230 ft^3/s, so the net stress on the aquifer was only decreased by 753 ft^3/s. Of the decreased net stress, 296 ft^3/s or 39 percent went to increased streamflow, 318 ft^3/s or 42 percent went to increased groundwater storage, and 98 ft^3/s or 13 percent went to increased evapotranspiration.

For the first decade of the analysis for the Eastern Model Unit, pumpage in the HCA/OA was decreased in the NPE by 122 ft^3/s. However, conversion of groundwater irrigated land to dryland also decreased recharge by 43 ft^3/s, so the net stress on the aquifer was only decreased by 79 ft^3/s. Of the decreased net stress, 29 ft^3/s or 37 percent went to increased streamflow, 42 ft^3/s or 53 percent went to increased groundwater storage, and 7 ft^3/s or 9 percent went to increased evapotranspiration. For the third decade of the analysis, pumpage in the HCA/OA was decreased by 122 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 44 ft^3/s, so the net stress on the aquifer was only decreased by 78 ft^3/s. Of the decreased net stress, 49 ft^3/s or 63 percent went to increased streamflow, 20 ft^3/s or 26 percent went to increased groundwater storage, and 10 ft^3/s or 13 percent went to increased evapotranspiration. For the fifth decade of the analysis, pumpage in the HCA/OA was decreased by 122 ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 44 ft^3/s, so the net stress on the aquifer was only decreased by 78 ft^3/s. Of the decreased net stress, 55 ft^3/s or 71 percent went to increased streamflow, 13 ft^3/s or 17 percent went to increased groundwater storage, and 11 ft^3/s or 14 percent went to increased evapotranspiration.

For the first decade of the analysis for the Eastern Model Unit, pumpage in the entire COHYST area was decreased in the NPE by 2,170 ft^3/s. However, conversion of groundwater irrigated land to dryland also decreased recharge by 1,397 ft^3/s, so the net stress on the aquifer was only decreased by 773 ft^3/s. Of the decreased net stress, 134 ft^3/s or 17 percent went to increased streamflow, 591 ft^3/s or 76 percent went to increased groundwater storage, and 82 ft^3/s or 11 percent went to increased evapotranspiration. For the third decade of the analysis, pumpage in the entire COHYST area was decreased by 2,170ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 1,397ft^3/s, so the net stress on the aquifer was only decreased by 773 ft^3/s. Of the decreased net stress, 291 ft^3/s or 38 percent went to increased streamflow, 364 ft^3/s or 47 percent went to increased groundwater storage, and 147 ft^3/s or 19 percent went to increased evapotranspiration. For the fifth decade of the analysis, pumpage in the entire COHYST area was decreased by 2,170ft^3/s. However, conversion of irrigated land to dryland also decreased recharge by 1,396 ft^3/s, so the net stress on the aquifer was only decreased by 774 ft^3/s. Of the decreased net stress, 381 ft^3/s or 49 percent went to increased streamflow, 248 ft^3/s or 32 percent went to increased groundwater storage, and 170 ft^3/s or 22 percent went to increased evapotranspiration.

Note that the differences in the water budgets of the three model units (fig. 1) cannot be summed to get an overall difference in water budgets. This is because of the large area of overlap between the model units.

Limitations and Comments

At the time of this analysis, COHYST had not yet completed estimates of use of supplemental groundwater on surface-water irrigated land, so the use of supplemental groundwater was ignored in this analysis. The use of supplemental groundwater is known to exist and has become more common in recent years. Water use on groundwater irrigated land varies primarily with local meteorological conditions, whereas supplemental groundwater use on surface-water irrigated land varies primarily with surface-water supply. If no change in use of supplemental groundwater on surface-water irrigated land occurred as groundwater irrigated land was reduced, ignoring supplemental water has no effect on the analysis because it was ignored in all simulations. In reality, if groundwater irrigated land were to be reduced in the future, some reduction of supplemental groundwater on surface-water irrigated land probably also would occur. However, without knowing how these two reductions would be linked, it is difficult to predict the effects of ignoring supplemental groundwater use on this analysis.

The results of this analysis are probably affected by evapotranspiration of shallow groundwater, particularly near and downstream of U.S. Highway 183. Evapotranspiration is simulated in the models in areas where the groundwater is near land surface or in areas of riparian vegetation near large rivers and streams. While model calibration required evapotranspiration in these areas, model calibration was not particularly sensitive to the various evapotranspiration parameters. As a result, evapotranspiration parameters were not well constrained by model calibration. In some areas, reduction in groundwater irrigated land may increase the amount of evapotranspiration instead of increasing stream baseflow. Simulated stream baseflow is directly affected by the evapotranspiration parameters used in the models, so any errors in evapotranspiration parameters would cause some errors in simulated stream baseflow. Because the area of interest in this analysis is upstream from U.S. Highway 183, errors in evapotranspiration parameters may not have a large effect on the analysis.

The analysis accounted for change in recharge as irrigated land was converted to dryland, and the recharge rates for irrigated land and dryland were from the calibrated models. The large differences in recharge rates between irrigated land and dryland substantially affected the analysis of stream baseflow effects due to converting irrigated land to dryland. The calibrated models should be examined to see if the recharge rates for irrigated land and dryland are unique or if other rates result in equally good calibrations. If other rates with smaller differences between irrigated land and dryland recharge result in satisfactory calibrations, this analysis may be underestimating the stream baseflow effects of reducing irrigated land.

The models used in this analysis were calibrated in two phases, a pre-groundwater development period and a groundwater development period. The former period was prior to 1950 and the latter period was after 1950. The pre-groundwater development period models were calibrated to both observed water levels and estimated stream baseflows. The groundwater development period models were only calibrated to observed water-level changes, because stream baseflow changes were thought to be generally small. Therefore, the effects of the increase in groundwater pumping through the development period on stream baseflows in the model were not compared to actual baseflows for this time. The analysis in this report looks at the response of stream baseflow to a change in groundwater irrigated land, and hence pumpage. Because the model calibrations did not include a comparison of modeled stream baseflow changes, it is difficult to assess the absolute accuracy of the results presented here, although the trends seem reasonable.

The calibrated model used for the Western Model Unit had 593 dry cells at the start of the analysis, particularly in Pumpkin Creek valley and it tributary valleys. Dry cells in the model are inactive, meaning that these cells have no pumpage from or recharge to them and water cannot move through these cells. Additional cells were simulated as going dry during this analysis, primarily cells in Pumpkin Creek valley, its tributary valleys, and parts of Lodgepole Creek valley, including its tributary valley Sidney Draw. Up to 132 additional cells went dry during the simulation. The dry cells were generally in areas of small saturated thickness, and thus little groundwater irrigation, and probably had little effect on the results.

Future meteorological conditions may not be adequately represented by the meteorological conditions used in this analysis. The Twentieth Century probably was wetter than previous centuries and tended to have shorter droughts. In addition, future climates may be different from the present climate.

The results of this analysis are more reliable in earlier time and less reliable in later time. This is because there is an accumulation of model errors as the simulations progress, although these errors are generally small.

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Table 1. Groundwater irrigated land for 1997 in the Cooperative Hydrology Study (COHYST) area and in the Hydrologically Connected Area of the Over Appropriated Basin (HCA/OA) by county. Total may be different from sum of numbers because of rounding.

County	Area (acres)	Percent in COHYST	Groundwater irrigated land (acres)	
			Inside COHYST	Inside HCA/OA
Adams	360,900	100	184,670	0
Arthur	459,400	90	11,650	0
Banner	477,300	100	26,860	21,220
Box Butte	689,400	64	110,640	0
Buffalo	623,800	88	208,400	2,800
Butler	376,400	0	0	0
Chase	574,300	68	120,950	0
Cheyenne	765,200	100	54,600	17,430
Clay	366,900	100	190,940	0
Custer	1,647,600	24	48,980	0
Dawson	652,000	100	155,130	50,300
Deuel	281,900	100	18,990	11,730
Franklin	368,700	79	74,050	0
Frontier	627,000	100	54,300	270
Furnas	461,100	22	11,350	0
Garden	1,107,100	99	27,990	15,410
Gosper	296,000	100	68,140	22,630
Grant	500,900	17	490	0
Hall	353,200	100	205,270	0
Hamilton	349,700	100	239,240	0
Harlan	367,400	68	48,970	0
Hayes	456,400	96	44,250	0
Hitchcock	459,800	14	7,230	0
Howard	368,200	30	39,380	0
Kearney	330,200	100	173,760	0
Keith	709,800	100	82,410	57,720
Kimball	609,100	100	30,200	13,220
Lincoln	1,647,100	100	184,470	58,200
Logan	365,300	75	14,680	0
McPherson	550,000	55	8,630	2,890
Merrick	316,200	99	179,530	11,260
Morrill	914,500	100	61,820	41,410
Nance	286,600	24	19,100	0
Nuckolls	368,600	96	35,640	0
Perkins	565,600	100	131,240	0
Phelps	345,900	100	157,530	37,950
Platte	438,100	13	23,060	0
Polk	282,100	100	135,660	0
Red Willow	459,500	38	21,040	0
Scotts Bluff	476,800	100	7,190	4,980
Sheridan	1,580,200	16	2,900	0
Sioux	1,322,600	38	5,830	3,910
Webster	368,000	81	35,240	0
York	368,400	100	230,890	0
TOTAL	**25,295,200**	**74**	**3,493,290**	**262,080**

Table 2. Groundwater irrigated land for 1997 in the Cooperative Hydrology Study (COHYST) area and in the Hydrologically Connected Area of the Over Appropriated Basin (HCA/OA) by Natural Resources District. Total may be different from sum of numbers because of rounding.

Natural Resources District	Area (acres)	Percent in COHYST	Groundwater irrigated land (acres)	
			Inside COHYST	Inside HCA/OA
Central Platte	2,136,500	100	812,800	53,400
Little Blue	1,538,100	57	294,900	0
Lower Loup	5,092,000	11	128,000	0
Lower Republican	1,587,100	60	163,300	0
Middle Republican	2,428,100	71	192,700	0
North Platte	3,307,000	99	128,800	86,900
South Platte	1,661,000	100	103,800	42,400
Tri-Basin	971,700	100	399,400	60,600
Twin Platte	2,736,300	93	215,700	118,800
Upper Big Blue	1,830,900	58	670,800	0
Upper Loup	4,299,800	6	16,400	0
Upper Niobrara White	4,175,700	21	114,400	0
Upper Republican	1,730,500	55	252,200	0
TOTAL	**33,494,700**	**53**	**3,493,300**	**262,100**

Table 3. Stream baseflow in Platte River system due to the Pumping Effect (PE) and the No Pumping Effect (NPE) of pre-1998 pumpage for each area. Differences may not be the same as the difference between the numbers because of rounding. Total may be different from sum of numbers because of rounding. HCA/OA is Hydrologically Connected Area of the Over Appropriated Basin. Values for 1997 and 1998 are from calibrated models.

Date	Simulated stream baseflow, in cubic feet per second					
	Continued 1997 land use (PE)		No groundwater irrigation (NPE)		NPE minus PE (average conditions)	
	Average meteorological conditions	Variable meteorological conditions	In HCA/OA	Everywhere	In HCA/OA	Everywhere
Wyoming line to Kingsley Dam **A**						
Oct. 1, 1997	837	--	--	--	--	--
May 1, 1998	848	--	--	--	--	--
Oct. 1, 2001	834	833	859	859	25	25
May 1, 2002	849	847	860	860	12	12
Oct. 1, 2007	834	831	867	867	33	33
May 1, 2008	849	848	867	868	19	19
Oct. 1, 2013	834	837	871	872	36	37
May 1, 2014	849	850	871	872	22	23
Oct. 1, 2020	835	836	874	876	39	41
May 1, 2021	849	850	874	876	25	27
Oct. 1, 2027	835	836	876	879	41	44
May 1, 2028	849	849	876	879	27	30
Oct. 1, 2037	835	831	878	882	43	47
May 1, 2038	849	847	878	882	28	33
Oct. 1, 2047	835	842	879	885	44	50
May 1, 2048	850	854	879	885	30	35
Kingsley Day to Tri-County Supply Canal **B**						
Oct. 1, 1997	369	--	--	--	--	--
May 1, 1998	416	--	--	--	--	--
Oct. 1, 2001	351	330	427	428	75	76
May 1, 2002	402	392	428	430	27	28
Oct. 1, 2007	351	344	438	443	87	92
May 1, 2008	402	399	439	445	37	43
Oct. 1, 2013	351	360	443	453	92	102
May 1, 2014	401	403	443	454	42	53
Oct. 1, 2020	351	343	446	462	95	111
May 1, 2021	401	394	446	463	45	62
Oct. 1, 2027	351	350	448	470	97	119
May 1, 2028	402	395	448	471	46	69
Oct. 1, 2037	351	337	450	479	99	128
May 1, 2038	402	390	450	479	48	78
Oct. 1, 2047	351	361	452	486	100	135
May 1, 2048	402	401	452	486	50	84
Tri-County Supply Canal to Lexington **C**						
Oct. 1, 1997	281	--	--	--	--	--
May 1, 1998	317	--	--	--	--	--
Oct. 1, 2001	261	235	310	314	49	52
May 1, 2002	300	290	312	315	12	15
Oct. 1, 2007	262	265	318	327	56	65
May 1, 2008	301	307	319	328	18	26
Oct. 1, 2013	263	287	322	336	59	73
May 1, 2014	303	316	323	337	21	34
Oct. 1, 2020	264	271	325	345	61	81
May 1, 2021	304	310	326	346	22	42
Oct. 1, 2027	265	279	327	353	62	88
May 1, 2028	305	315	328	354	23	49
Oct. 1, 2037	266	278	329	363	63	97
May 1, 2038	306	316	330	364	25	58
Oct. 1, 2047	267	289	331	371	64	104
May 1, 2048	307	323	332	371	25	64

Table 3 continued.

Date	Simulated stream baseflow, in cubic feet per second					
	Continued 1997 land use (PE)		No groundwater irrigation (NPE)		NPE minus PE (average conditions)	
	Average meteorological conditions	Variable meteorological conditions	In HCA/OA	Everywhere	In HCA/OA	Everywhere
Lexington to U.S. Highway 183 **C**						
Oct. 1, 1997	44	--	--	--	--	--
May 1, 1998	53	--	--	--	--	--
Oct. 1, 2001	45	40	60	62	15	17
May 1, 2002	54	51	61	63	7	9
Oct. 1, 2007	48	46	67	70	20	23
May 1, 2008	57	55	68	71	11	14
Oct. 1, 2013	50	54	72	76	22	26
May 1, 2014	59	60	73	77	14	18
Oct. 1, 2020	53	53	77	82	24	29
May 1, 2021	61	61	77	82	15	20
Oct. 1, 2027	55	55	80	86	25	31
May 1, 2028	64	63	80	86	17	22
Oct. 1, 2037	57	59	83	91	26	33
May 1, 2038	66	66	84	90	18	24
Oct. 1, 2047	59	66	86	94	27	35
May 1, 2048	68	73	86	94	18	26
Wyoming line to U.S. Highway 183 **TOTAL**						
Oct. 1, 1997	1,531	--	--	--	--	--
May 1, 1998	1,634	--	--	--	--	--
Oct. 1, 2001	1,492	1,438	1,656	1,662	164	170
May 1, 2002	1,605	1,580	1,662	1,668	57	63
Oct. 1, 2007	1,495	1,486	1,690	1,708	195	213
May 1, 2008	1,608	1,608	1,693	1,711	85	103
Oct. 1, 2013	1,499	1,538	1,708	1,738	209	239
May 1, 2014	1,612	1,629	1,710	1,740	98	128
Oct. 1, 2020	1,503	1,504	1,721	1,765	218	262
May 1, 2021	1,616	1,616	1,723	1,767	107	151
Oct. 1, 2027	1,506	1,519	1,731	1,788	225	282
May 1, 2028	1,619	1,622	1,732	1,789	113	170
Oct. 1, 2037	1,510	1,504	1,741	1,815	231	305
May 1, 2038	1,623	1,620	1,742	1,816	119	193
Oct. 1, 2047	1,513	1,558	1,748	1,836	235	323
May 1, 2048	1,626	1,651	1,749	1,837	123	210

Table 4. Stream baseflow in Platte River system due to reducing groundwater irrigated land inside the Hydrologically Connected Area of the Over Appropriated Basin after 1997. Total may be different from sum of numbers because of rounding. Differences cited in text may be different from differences between these numbers because of rounding. Values for 1997 and 1998 are from calibrated models.

Date	Stream baseflow, in cubic feet per second					
	0% reduction	20% reduction	40% reduction	60% reduction	80% reduction	100% reduction
Wyoming line to Kingsley Dam **A**						
Oct. 1, 1997	837	--	--	--	--	--
May 1, 1998	848	--	--	--	--	--
Oct. 1, 2001	834	839	844	849	854	859
May 1, 2002	849	851	853	856	858	860
Oct. 1, 2007	834	840	846	853	860	867
May 1, 2008	849	852	856	859	864	867
Oct. 1, 2013	834	841	848	855	863	871
May 1, 2014	849	852	857	861	867	871
Oct. 1, 2020	835	841	849	857	866	874
May 1, 2021	849	853	858	863	869	874
Oct. 1, 2027	835	842	849	858	867	876
May 1, 2028	849	853	859	864	871	876
Oct. 1, 2037	835	842	850	859	869	878
May 1, 2038	849	854	859	865	872	878
Oct. 1, 2047	835	842	850	859	870	879
May 1, 2048	850	854	860	866	874	879
Kingsley Dam to Tri-County Supply Canal **B**						
Oct. 1, 1997	369	--	--	--	--	--
May 1, 1998	416	--	--	--	--	--
Oct. 1, 2001	351	366	381	396	411	427
May 1, 2002	402	407	413	417	423	428
Oct. 1, 2007	351	368	385	402	420	438
May 1, 2008	402	409	417	424	431	439
Oct. 1, 2013	351	369	387	405	424	443
May 1, 2014	401	410	419	426	435	443
Oct. 1, 2020	351	370	389	407	426	446
May 1, 2021	401	411	420	428	437	446
Oct. 1, 2027	351	370	390	408	428	448
May 1, 2028	402	411	421	430	439	448
Oct. 1, 2037	351	371	390	410	430	450
May 1, 2038	402	412	422	431	441	450
Oct. 1, 2047	351	371	391	410	431	452
May 1, 2048	402	412	422	432	442	452
Tri-County Supply Canal to Lexington **C**						
Oct. 1, 1997	281	--	--	--	--	--
May 1, 1998	317	--	--	--	--	--
Oct. 1, 2001	261	271	281	290	300	310
May 1, 2002	300	303	305	307	310	312
Oct. 1, 2007	262	273	284	295	307	318
May 1, 2008	301	305	309	312	316	319
Oct. 1, 2013	263	275	287	298	310	322
May 1, 2014	303	307	311	315	319	323
Oct. 1, 2020	264	276	288	300	313	325
May 1, 2021	304	308	313	317	321	326
Oct. 1, 2027	265	278	290	302	314	327
May 1, 2028	305	310	315	319	323	328
Oct. 1, 2037	266	279	292	304	317	329
May 1, 2038	306	311	316	320	325	330
Oct. 1, 2047	267	280	293	305	319	331
May 1, 2048	307	312	317	322	327	332

Table 4 continued.

Date	Stream baseflow, in cubic feet per second					
	0% reduction	20% reduction	40% reduction	60% reduction	80% reduction	100% reduction
Lexington to U.S. Highway 183 **D**						
Oct. 1, 1997	44	--	--	--	--	--
May 1, 1998	53	--	--	--	--	--
Oct. 1, 2001	45	48	51	54	57	60
May 1, 2002	54	55	57	58	60	61
Oct. 1, 2007	48	52	55	59	63	67
May 1, 2008	57	59	61	63	66	68
Oct. 1, 2013	50	55	59	63	68	72
May 1, 2014	59	62	64	67	70	73
Oct. 1, 2020	53	57	62	67	72	77
May 1, 2021	61	64	68	71	74	77
Oct. 1, 2027	55	60	65	70	75	80
May 1, 2028	64	67	70	73	77	80
Oct. 1, 2037	57	62	68	73	78	83
May 1, 2038	66	69	73	77	80	84
Oct. 1, 2047	59	64	70	75	81	86
May 1, 2048	68	71	75	79	83	86
TOTAL, Wyoming line to U.S. Highway 183						
Oct. 1, 1997	1,531	--	--	--	--	--
May 1, 1998	1,634	--	--	--	--	--
Oct. 1, 2001	1,492	1,524	1,557	1,589	1,622	1,656
May 1, 2002	1,605	1,617	1,628	1,638	1,650	1,662
Oct. 1, 2007	1,495	1,533	1,572	1,610	1,650	1,690
May 1, 2008	1,608	1,625	1,642	1,658	1,676	1,693
Oct. 1, 2013	1,499	1,539	1,581	1,622	1,665	1,708
May 1, 2014	1,612	1,631	1,651	1,670	1,690	1,710
Oct. 1, 2020	1,503	1,545	1,588	1,631	1,677	1,721
May 1, 2021	1,616	1,637	1,658	1,679	1,702	1,723
Oct. 1, 2027	1,506	1,549	1,594	1,638	1,685	1,731
May 1, 2028	1,619	1,641	1,664	1,686	1,710	1,732
Oct. 1, 2037	1,510	1,554	1,600	1,645	1,694	1,741
May 1, 2038	1,623	1,646	1,670	1,693	1,718	1,742
Oct. 1, 2047	1,513	1,558	1,604	1,650	1,700	1,748
May 1, 2048	1,626	1,650	1,674	1,698	1,725	1,749

Table 5. Stream baseflow in Platte River system due to reducing groundwater irrigated land everywhere after 1997. Total may be different from sum of numbers because of rounding. Differences cited in text may be different from differences between these numbers because of rounding. Values for 1997 and 1998 are from calibrated models.

Date	Stream baseflow, in cubic feet per second					
	0% reduction	20% reduction	40% reduction	60% reduction	80% reduction	100% reduction
Wyoming line to Kingsley Dam **A**						
Oct. 1, 1997	837	--	--	--	--	--
May 1, 1998	848	--	--	--	--	--
Oct. 1, 2001	834	839	844	849	854	859
May 1, 2002	849	851	853	856	858	860
Oct. 1, 2007	834	840	847	853	860	867
May 1, 2008	849	852	856	860	864	868
Oct. 1, 2013	834	841	848	856	864	872
May 1, 2014	849	853	858	862	867	872
Oct. 1, 2020	835	842	850	858	867	876
May 1, 2021	849	854	859	864	870	876
Oct. 1, 2027	835	842	851	859	869	879
May 1, 2028	849	854	860	866	872	879
Oct. 1, 2037	835	843	852	861	871	882
May 1, 2038	849	855	861	868	875	882
Oct. 1, 2047	835	843	853	863	873	885
May 1, 2048	850	855	862	869	877	885
Kingsley Dam to Tri-County Supply Canal **B**						
Oct. 1, 1997	369	--	--	--	--	--
May 1, 1998	416	--	--	--	--	--
Oct. 1, 2001	351	366	381	396	412	428
May 1, 2002	402	408	413	418	424	430
Oct. 1, 2007	351	369	387	405	424	443
May 1, 2008	402	410	419	427	436	445
Oct. 1, 2013	351	371	391	411	432	453
May 1, 2014	401	412	423	433	444	454
Oct. 1, 2020	351	373	395	416	439	462
May 1, 2021	401	414	427	438	451	463
Oct. 1, 2027	351	374	398	421	445	470
May 1, 2028	402	415	429	443	457	471
Oct. 1, 2037	351	376	401	426	452	479
May 1, 2038	402	417	433	448	463	479
Oct. 1, 2047	351	377	404	430	457	486
May 1, 2048	402	419	436	452	469	486
Tri-County Supply Canal to Lexington **C**						
Oct. 1, 1997	281	--	--	--	--	--
May 1, 1998	317	--	--	--	--	--
Oct. 1, 2001	261	272	282	293	303	314
May 1, 2002	300	304	307	309	312	315
Oct. 1, 2007	262	275	288	300	313	327
May 1, 2008	301	307	312	317	322	328
Oct. 1, 2013	263	277	292	306	321	336
May 1, 2014	303	309	316	323	329	337
Oct. 1, 2020	264	280	296	311	328	345
May 1, 2021	304	312	320	328	336	346
Oct. 1, 2027	265	282	299	316	334	353
May 1, 2028	305	314	323	332	343	354
Oct. 1, 2037	266	284	303	321	342	363
May 1, 2038	306	316	327	338	351	364
Oct. 1, 2047	267	286	306	327	349	371
May 1, 2048	307	318	330	343	357	371

Table 5 continued.

Date	Stream baseflow, in cubic feet per second					
	0% reduction	20% reduction	40% reduction	60% reduction	80% reduction	100% reduction
Lexington to U.S. Highway 183 **D**						
Oct. 1, 1997	44	--	--	--	--	--
May 1, 1998	53	--	--	--	--	--
Oct. 1, 2001	45	49	52	55	59	62
May 1, 2002	54	56	57	59	61	63
Oct. 1, 2007	48	52	57	61	66	70
May 1, 2008	57	59	62	65	68	71
Oct. 1, 2013	50	55	60	66	71	76
May 1, 2014	59	62	66	69	73	77
Oct. 1, 2020	53	58	64	70	76	82
May 1, 2021	61	65	69	73	78	82
Oct. 1, 2027	55	61	67	73	79	86
May 1, 2028	64	68	72	77	81	86
Oct. 1, 2037	57	64	70	77	84	91
May 1, 2038	66	71	75	80	85	90
Oct. 1, 2047	59	66	73	80	87	94
May 1, 2048	68	73	78	83	89	94
TOTAL, Wyoming line to U.S. Highway 183						
Oct. 1, 1997	1,531	--	--	--	--	--
May 1, 1998	1,634	--	--	--	--	--
Oct. 1, 2001	1,492	1,526	1,560	1,593	1,627	1,662
May 1, 2002	1,605	1,618	1,631	1,642	1,655	1,668
Oct. 1, 2007	1,495	1,536	1,578	1,620	1,664	1,708
May 1, 2008	1,608	1,629	1,649	1,669	1,690	1,711
Oct. 1, 2013	1,499	1,545	1,592	1,639	1,688	1,738
May 1, 2014	1,612	1,637	1,662	1,687	1,713	1,740
Oct. 1, 2020	1,503	1,553	1,604	1,655	1,709	1,765
May 1, 2021	1,616	1,645	1,674	1,703	1,734	1,767
Oct. 1, 2027	1,506	1,559	1,614	1,669	1,728	1,788
May 1, 2028	1,619	1,651	1,685	1,717	1,753	1,789
Oct. 1, 2037	1,510	1,567	1,626	1,686	1,749	1,815
May 1, 2038	1,623	1,659	1,696	1,734	1,774	1,816
Oct. 1, 2047	1,513	1,573	1,636	1,700	1,766	1,836
May 1, 2048	1,626	1,665	1,706	1,748	1,791	1,837

Table 6. Differences in stream baseflow in the Platte River system due to reducing groundwater irrigated land everywhere versus only in the Hydrologically Connected Area of the Over Appropriated Basin after 1997. Total may be different from sum of numbers because of rounding. Difference may not be the same as the difference between tables 4 and 5 because of rounding.

Date	Difference in stream baseflow, in cubic feet per second				
	20% reduction	40% reduction	60% reduction	80% reduction	100% reduction
Wyoming line to Kingsley Dam **A**					
Oct. 1, 2001	0	0	0	0	0
May 1, 2002	0	0	0	0	0
Oct. 1, 2007	0	0	0	0	0
May 1, 2008	0	0	0	0	0
Oct. 1, 2013	0	1	1	0	1
May 1, 2014	0	1	1	0	1
Oct. 1, 2020	1	1	1	1	2
May 1, 2021	1	1	1	1	2
Oct. 1, 2027	1	1	2	1	3
May 1, 2028	1	1	2	1	3
Oct. 1, 2037	1	2	3	2	4
May 1, 2038	1	2	3	2	4
Oct. 1, 2047	1	2	3	3	6
May 1, 2048	1	2	3	3	6
Kingsley Dam to Tri-County Supply Canal **B**					
Oct. 1, 2001	0	0	1	1	1
May 1, 2002	0	0	1	1	1
Oct. 1, 2007	1	2	3	4	5
May 1, 2008	1	2	3	5	6
Oct. 1, 2013	2	4	6	8	11
May 1, 2014	2	4	6	9	11
Oct. 1, 2020	3	6	9	13	16
May 1, 2021	3	6	10	13	17
Oct. 1, 2027	4	8	12	17	22
May 1, 2028	4	9	13	18	22
Oct. 1, 2037	5	11	16	22	29
May 1, 2038	6	11	17	23	29
Oct. 1, 2047	6	13	20	27	34
May 1, 2048	7	14	21	27	35
Tri-County Supply Canal to Lexington **C**					
Oct. 1, 2001	1	1	2	3	3
May 1, 2002	1	1	2	2	3
Oct. 1, 2007	2	3	5	7	9
May 1, 2008	1	3	5	6	8
Oct. 1, 2013	2	5	8	11	14
May 1, 2014	2	5	8	10	14
Oct. 1, 2020	3	7	11	15	20
May 1, 2021	3	7	11	15	20
Oct. 1, 2027	4	9	14	20	26
May 1, 2028	4	8	14	19	26
Oct. 1, 2037	5	11	18	26	34
May 1, 2038	5	11	17	25	33
Oct. 1, 2047	6	14	21	30	40
May 1, 2048	6	13	21	30	39

Table 6 continued.

Date	Difference in stream baseflow, in cubic feet per second				
	20% reduction	40% reduction	60% reduction	80% reduction	100% reduction
Lexington to U.S. Highway 183 **D**					
Oct. 1, 2001	0	1	1	1	2
May 1, 2002	0	1	1	1	2
Oct. 1, 2007	1	1	2	2	3
May 1, 2008	1	1	2	2	3
Oct. 1, 2013	1	1	2	3	4
May 1, 2014	1	1	2	3	4
Oct. 1, 2020	1	2	3	4	5
May 1, 2021	1	2	3	4	5
Oct. 1, 2027	1	2	3	5	6
May 1, 2028	1	2	3	4	6
Oct. 1, 2037	1	3	4	6	7
May 1, 2038	1	3	4	5	7
Oct. 1, 2047	1	3	5	6	8
May 1, 2048	1	3	4	6	8
TOTAL, Wyoming line to U.S. Highway 183					
Oct. 1, 2001	1	3	4	5	6
May 1, 2002	1	3	4	5	6
Oct. 1, 2007	3	7	10	14	18
May 1, 2008	3	7	10	13	18
Oct. 1, 2013	5	11	17	23	30
May 1, 2014	6	11	17	23	30
Oct. 1, 2020	8	16	24	33	44
May 1, 2021	8	16	25	33	43
Oct. 1, 2027	10	20	31	43	57
May 1, 2028	10	20	32	43	57
Oct. 1, 2037	13	26	41	56	74
May 1, 2038	13	26	41	56	73
Oct. 1, 2047	15	32	49	66	88
May 1, 2048	16	32	50	66	87

Table 7. Differences between water budgets for the Pumping Effect and No Pumping Effect by model unit. All numbers are cubic feet per second. Reduced net stress is reduced pumpage minus reduced recharge and is the net effect on the aquifer of converting groundwater irrigated land to dryland. All numbers are cubic feet per second. Increased groundwater storage is the rate at which storage is increasing.

Simulation or decade	Reduced pumpage	Reduced recharge	Reduced net stress	Increased streamflow	Increased groundwater storage	Increased evapotrans-piration
Pumping effect minus no pumping effect in Hydrologically Connected Area for the Overappropriated Basin – Western Model Unit						
1998-2008	173	61	112	38	70	4
2008-2018	170	60	110	56	48	6
2018-2028	167	60	107	63	38	6
2028-2038	165	58	107	68	32	7
2038-2048	162	57	105	71	27	8
Pumping effect minus no pumping effect in entire COHYST area – Western Model Unit						
1998-2008	448	145	303	38	245	20
2008-2018	444	143	301	59	204	38
2018-2028	441	142	299	69	182	48
2028-2038	438	141	297	76	165	55
2038-2048	435	140	295	81	152	61
Pumping effect minus no pumping effect in Hydrologically Connected Area for the Overappropriated Basin – Central Model Unit						
1998-2008	232	60	172	83	71	18
2008-2018	232	60	172	107	42	23
2018-2028	233	60	173	114	34	24
2028-2038	234	61	173	119	26	25
2038-2048	234	62	172	121	22	25
Pumping effect minus no pumping effect in entire COHYST area – Central Model Unit						
1998-2008	983	221	762	110	597	49
2008-2018	983	222	761	180	500	69
2018-2028	983	226	757	227	436	81
2028-2038	983	226	757	266	386	90
2038-2048	983	230	753	296	318	98
Pumping effect minus no pumping effect in Hydrologically Connected Area for the Overappropriated Basin – Eastern Model Unit						
1998-2008	122	43	79	29	42	7
2008-2018	122	44	78	43	26	10
2018-2028	122	44	78	49	20	10
2028-2038	121	43	78	52	16	11
2038-2048	122	44	78	55	13	11
Pumping effect minus no pumping effect in entire COHYST area – Eastern Model Unit						
1998-2008	2,170	1,397	773	134	591	82
2008-2018	2,170	1,396	774	233	446	126
2018-2028	2,170	1,397	773	291	364	147
2028-2038	2,170	1,396	774	340	300	161
2038-2048	2,170	1,396	774	381	248	170

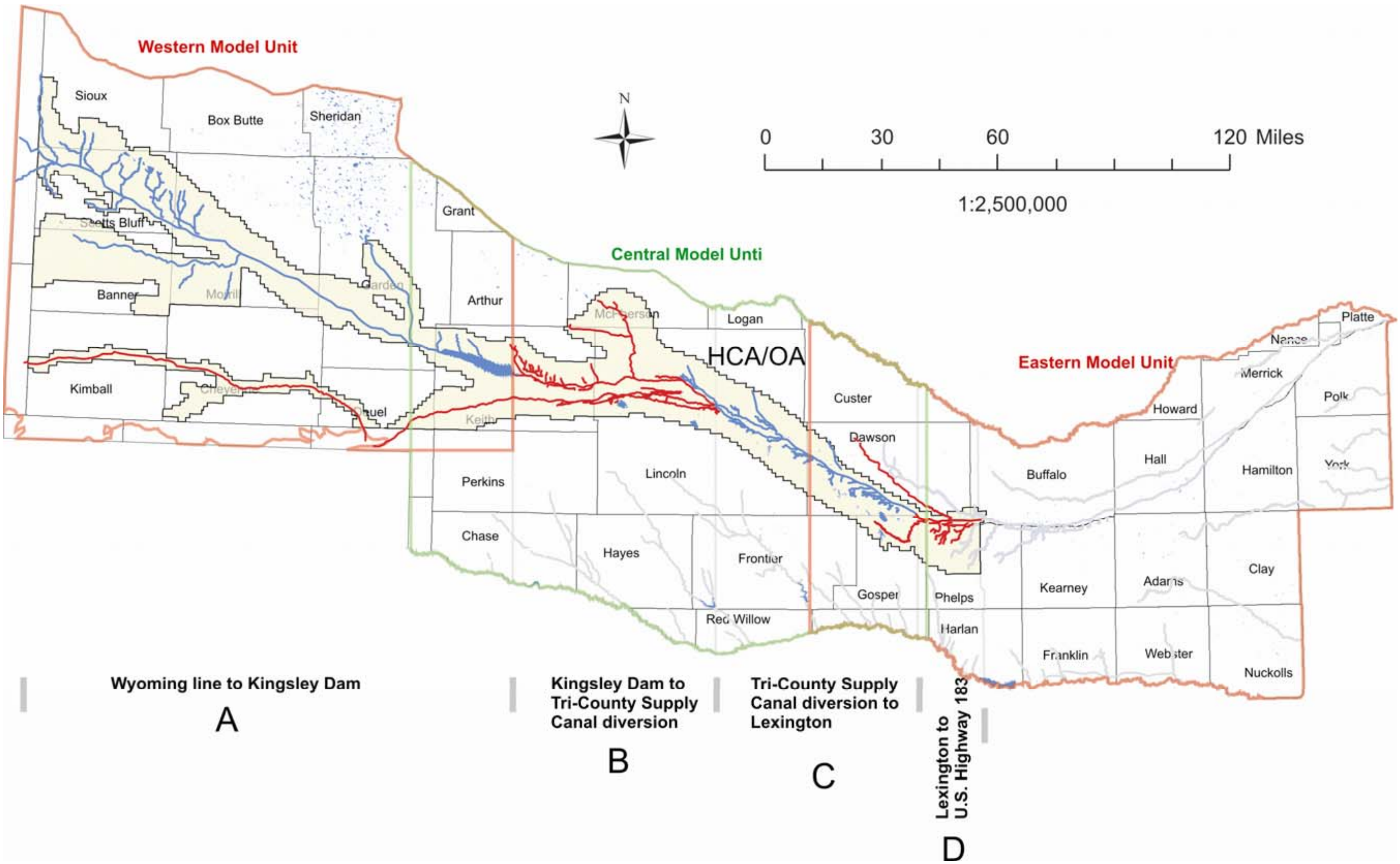


Figure 1. Cooperative Hydrology Study (COHYST) model units and the four sub-areas used in the analysis of stream baseflow to the Platte River system due to reductions in groundwater irrigated lands after 1997. Note that streams are grouped by the sub-area in which they reach the Platte River, including the North Platte River and South Platte River. HCA/OA is the Hydrologically Connected Area of the Overappropriated Basin.

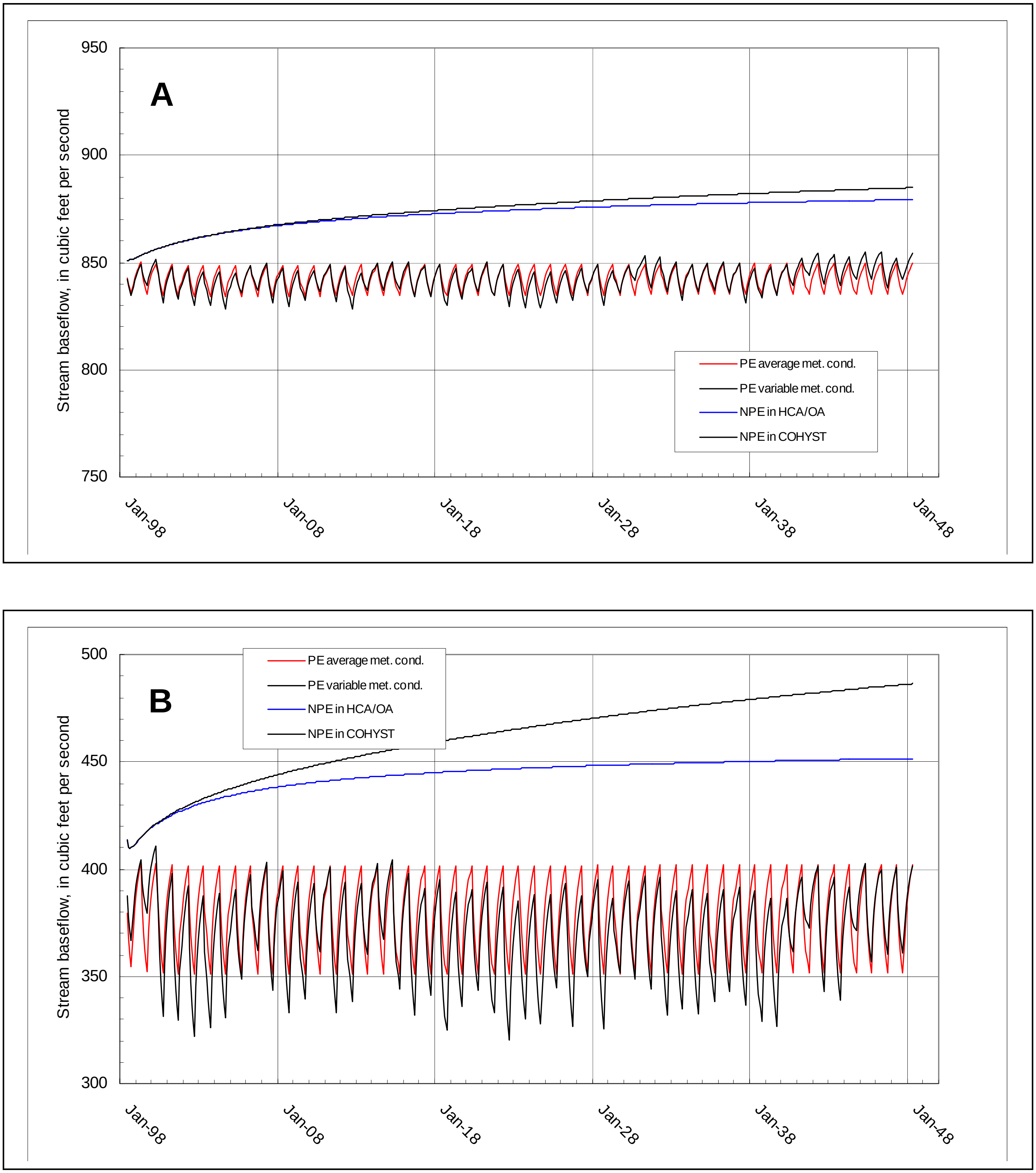
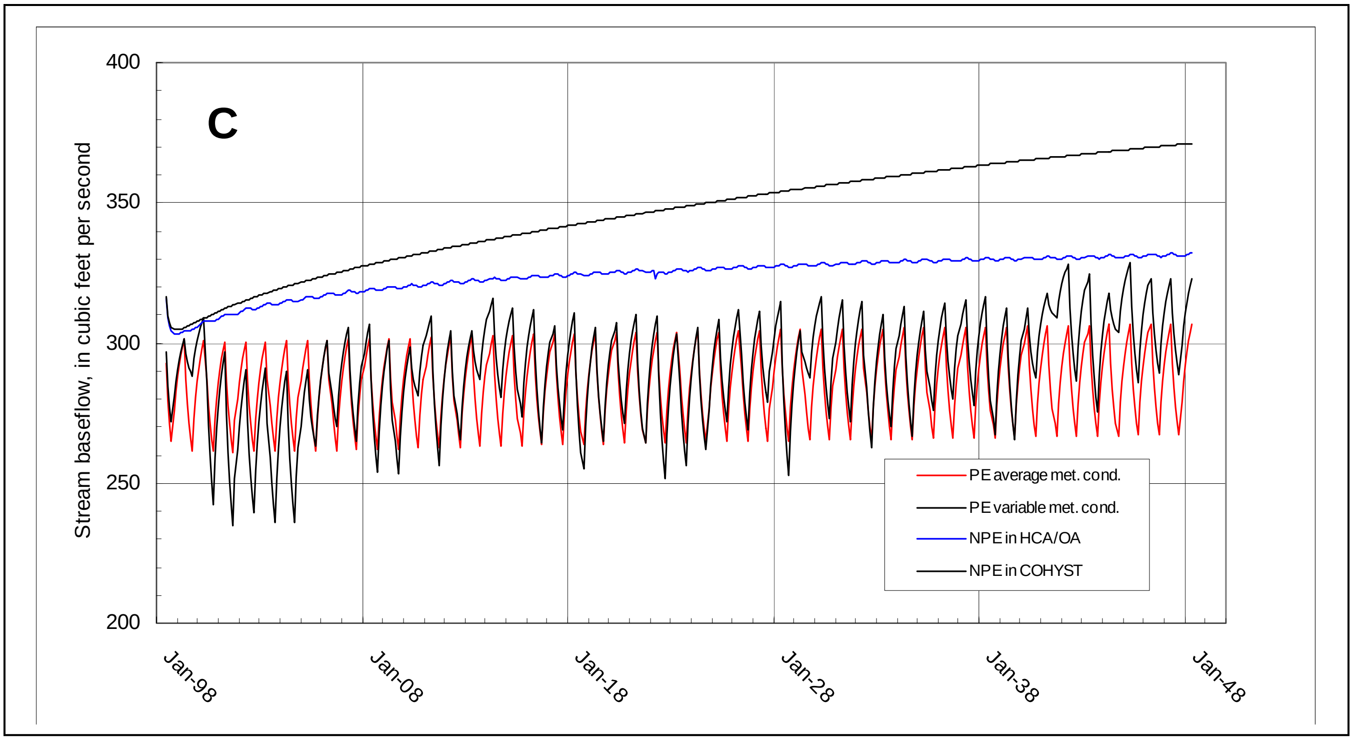


Figure 2. Comparison of simulated 1998-2048 stream baseflow with 1997 irrigated land held constant (lower graphs) and groundwater irrigated land converted to dryland (upper graphs) for each area. A) Wyoming line to Kingsley Dam; B) Kingsley Dam to Tri-County Supply Canal diversion; C) Tri-County Supply Canal diversion to Lexington; and D) Lexington to U.S. Highway 183. PE is Pumping Effect, NPE is No Pumping Effect, and HCA/OA is Hydrologically Connected Area of the Over-Appropriated Basin.



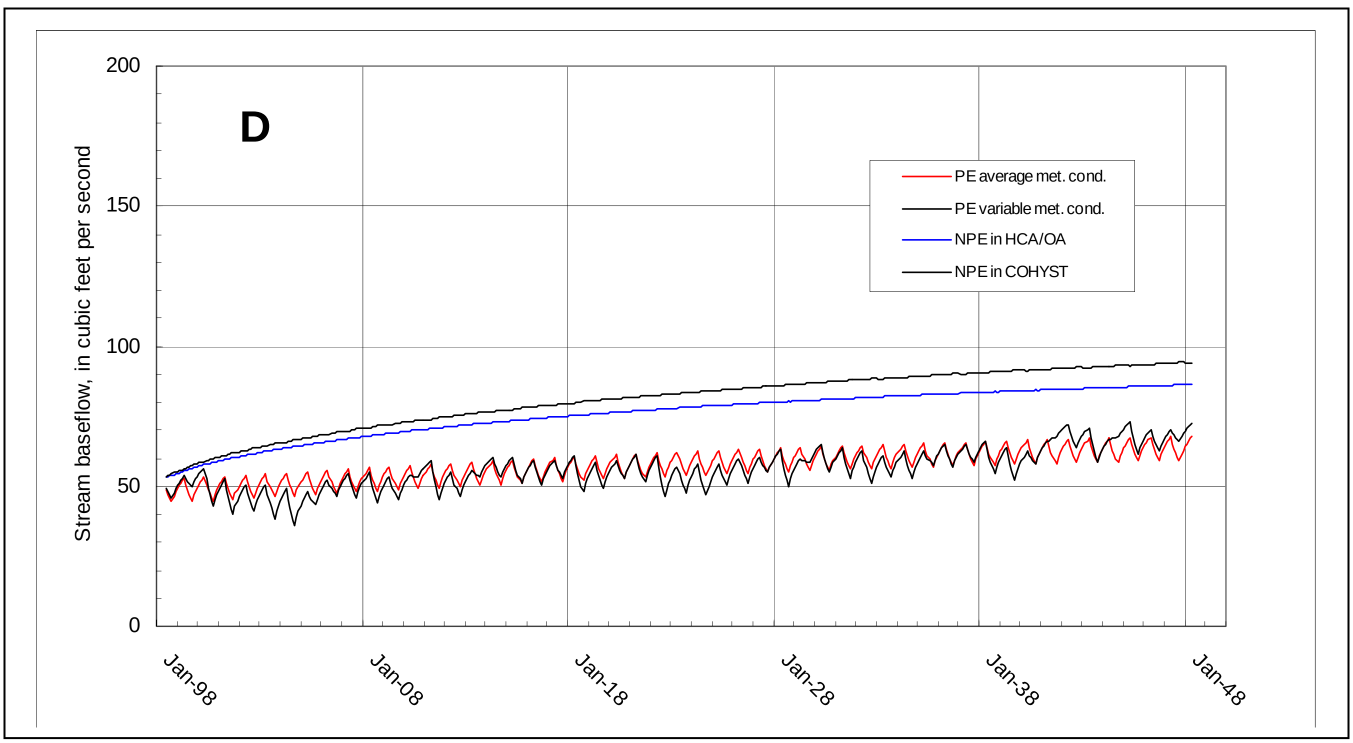
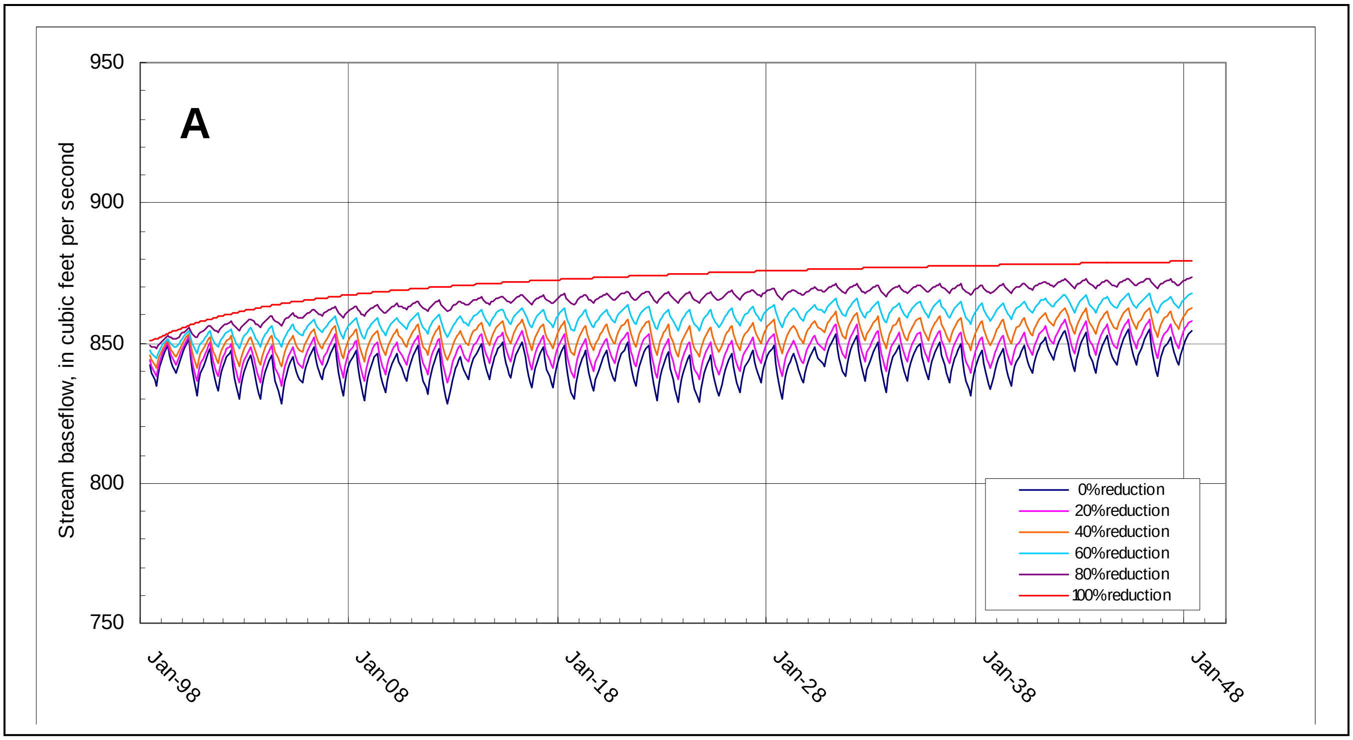


Figure 2 continued.



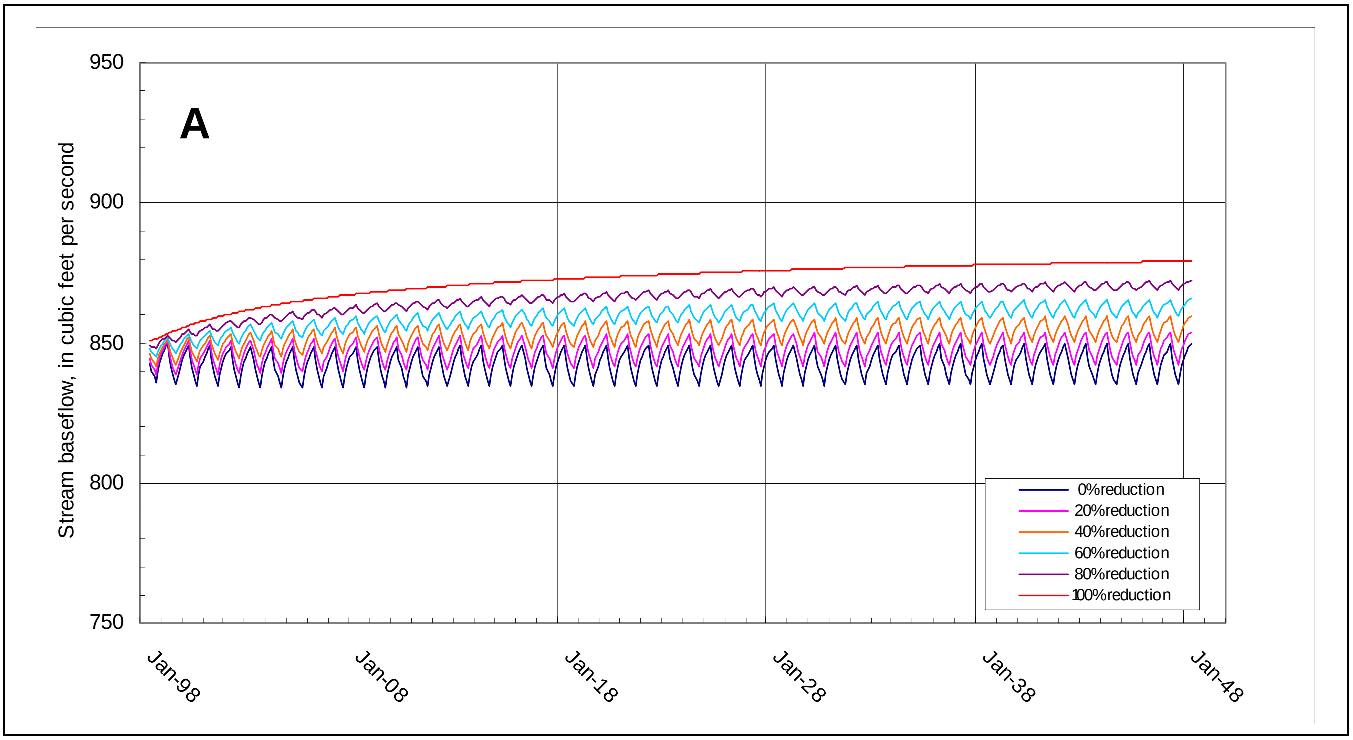
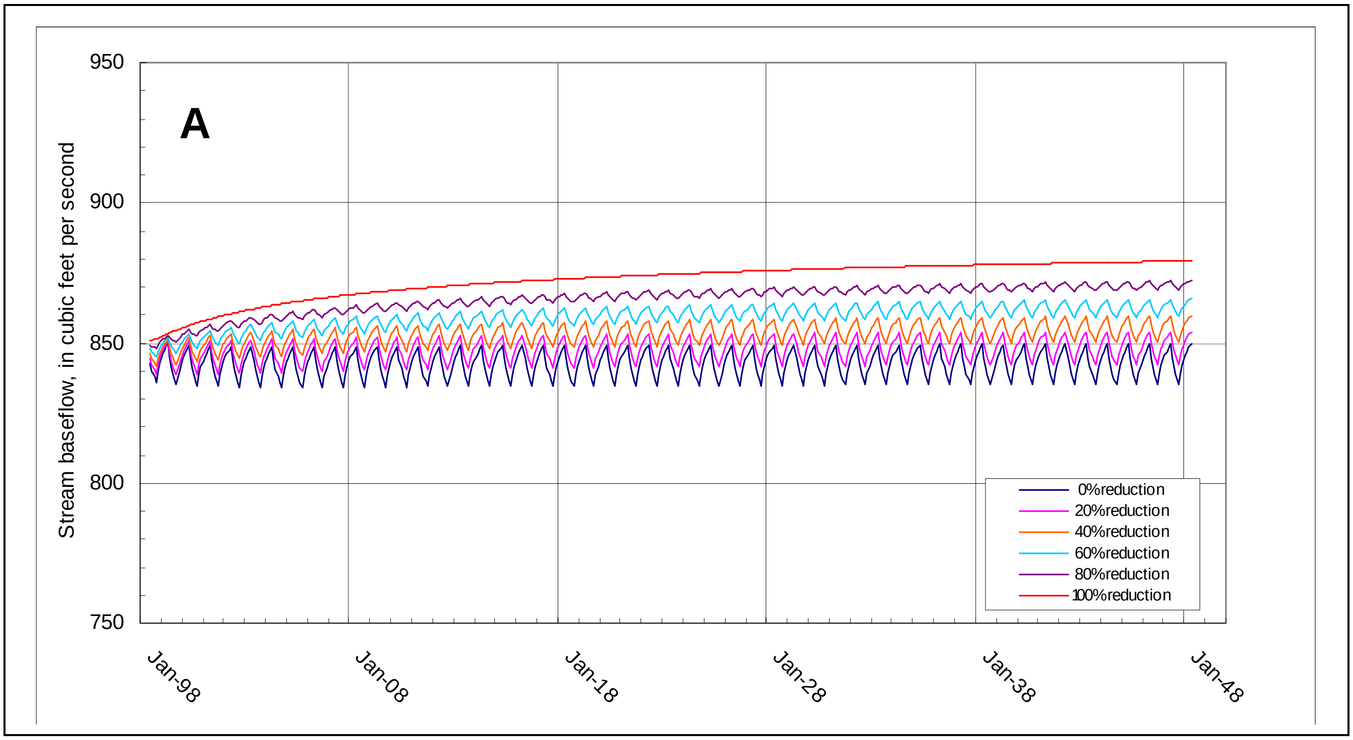


Figure 3. Simulated stream baseflow to the Platte River system due to reductions in groundwater irrigated lands in the Hydrologically Connected Area of the Over Appropriated Basin for Wyoming line to Kingsley Dam using variable meteorological data (upper graph) and average meteorological data (lower graph).



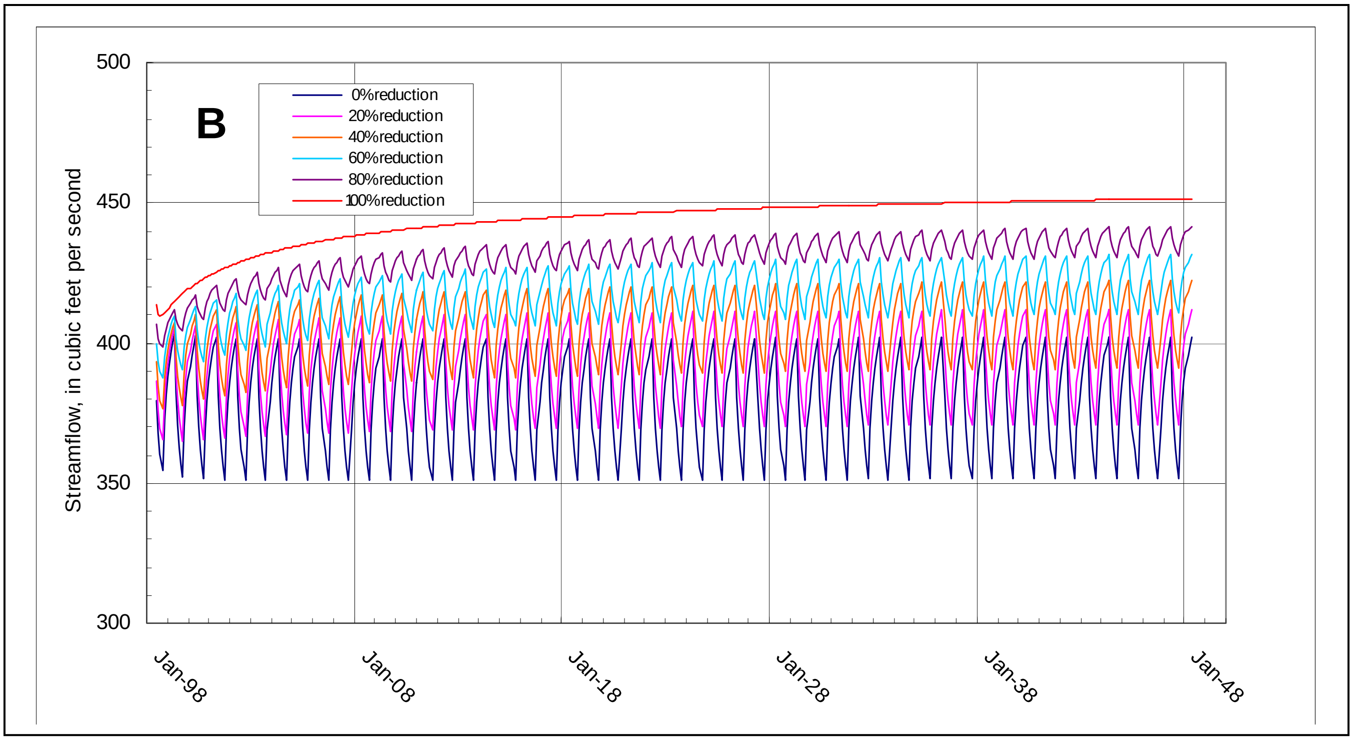
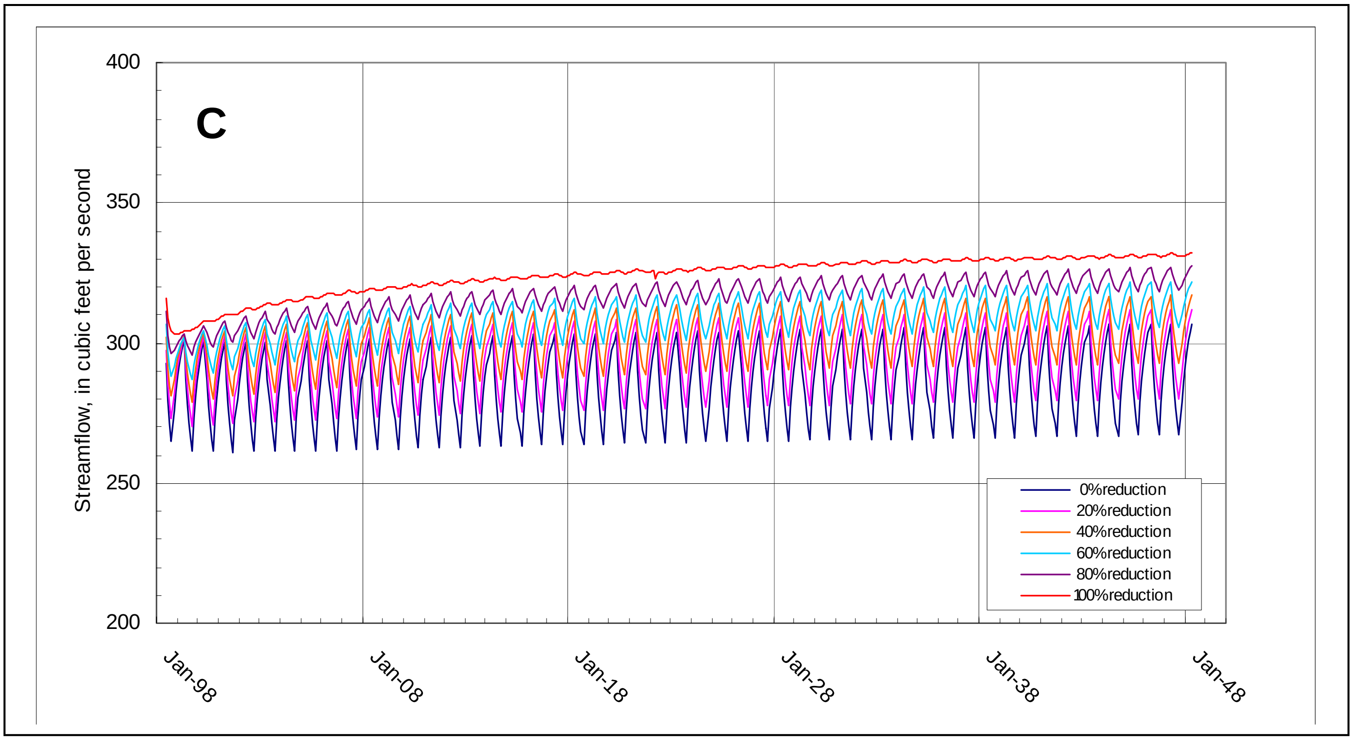


Figure 4. Simulated stream baseflow to the Platte River system due to reductions in groundwater irrigated lands in the Hydrologically Connected Area of the Over Appropriated Basin for each area. A) Wyoming line to Kingsley Dam; B) Kingsley Dam to Tri-County Supply Canal diversion; C) Tri-County Supply Canal diversion to Lexington; and D) Lexington to U.S. Highway 183.



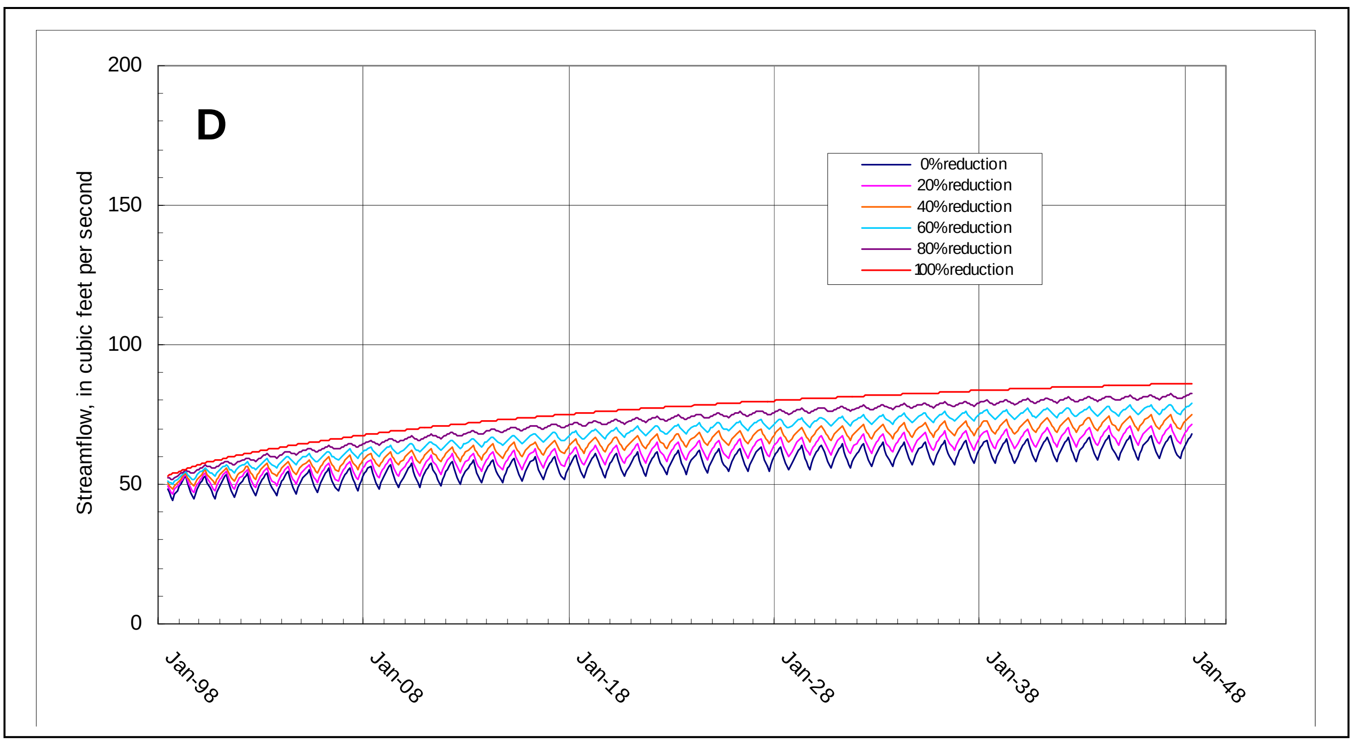
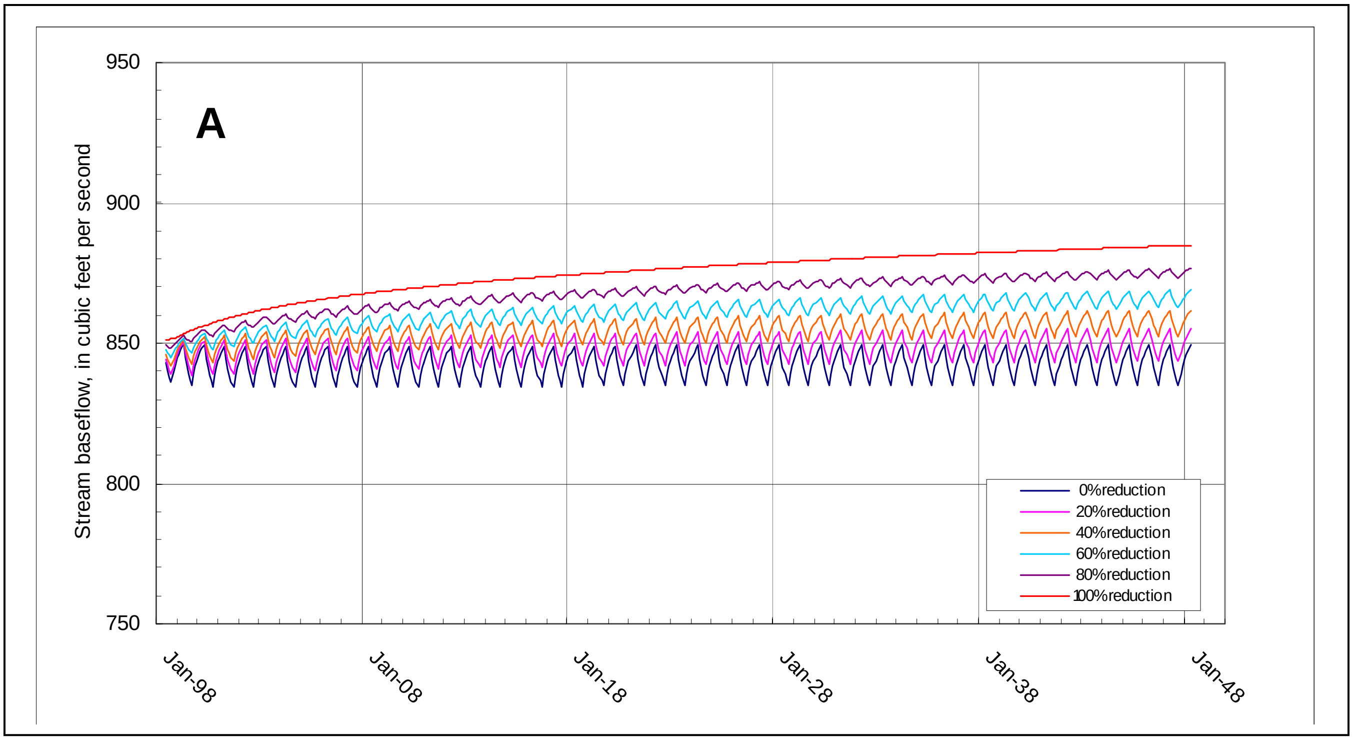


Figure 4 continued.



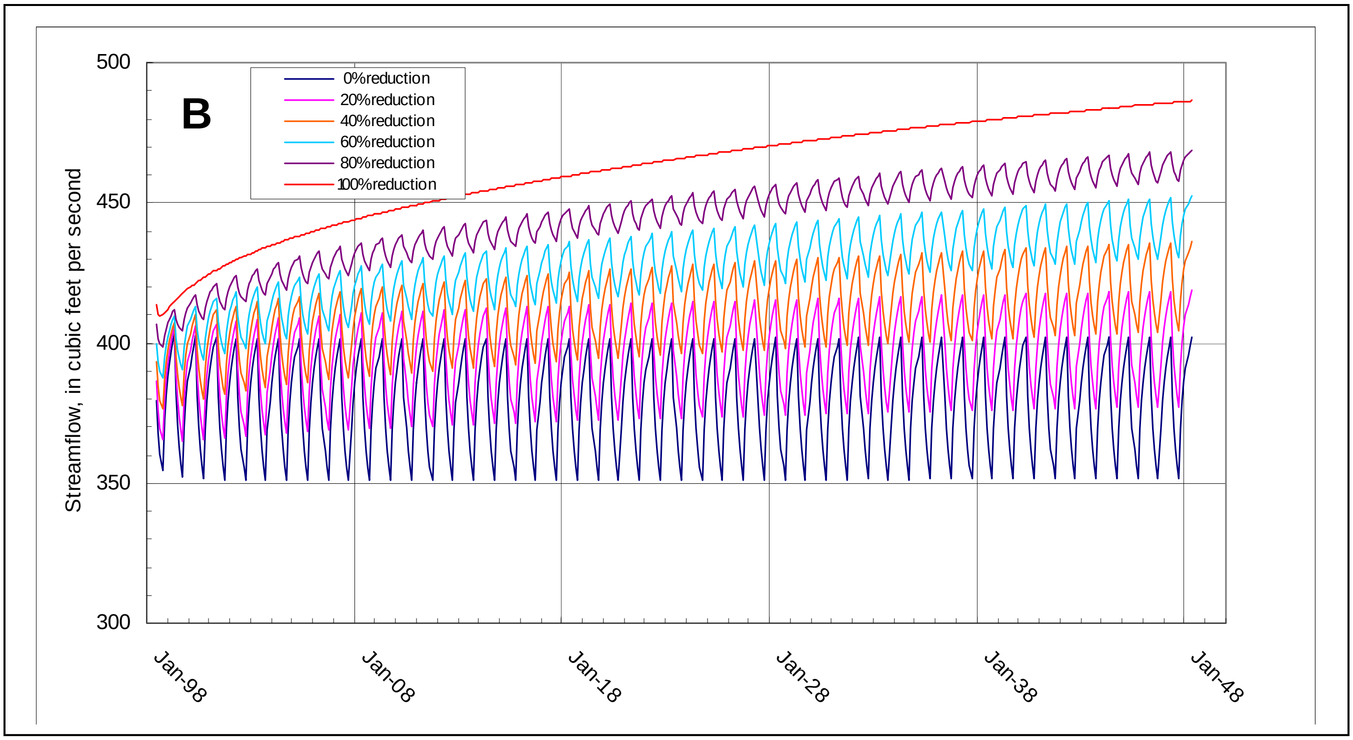
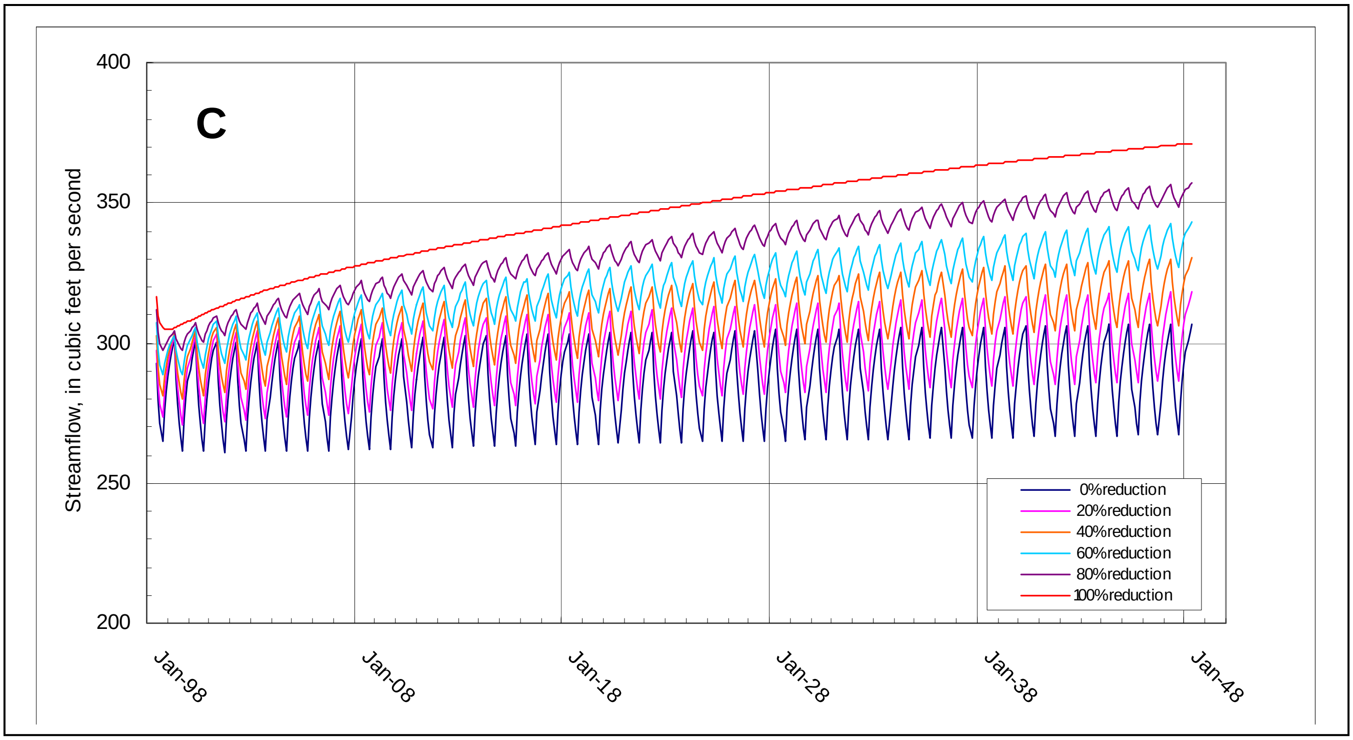


Figure 5. Stream baseflow to the Platte River system due to reductions in groundwater irrigated lands everywhere for each area. A) Wyoming line to Kingsley Dam; B) Kingsley Dam to Tri-County Supply Canal diversion; C) Tri-County Supply Canal diversion to Lexington; and D) Lexington to U.S. Highway 183.



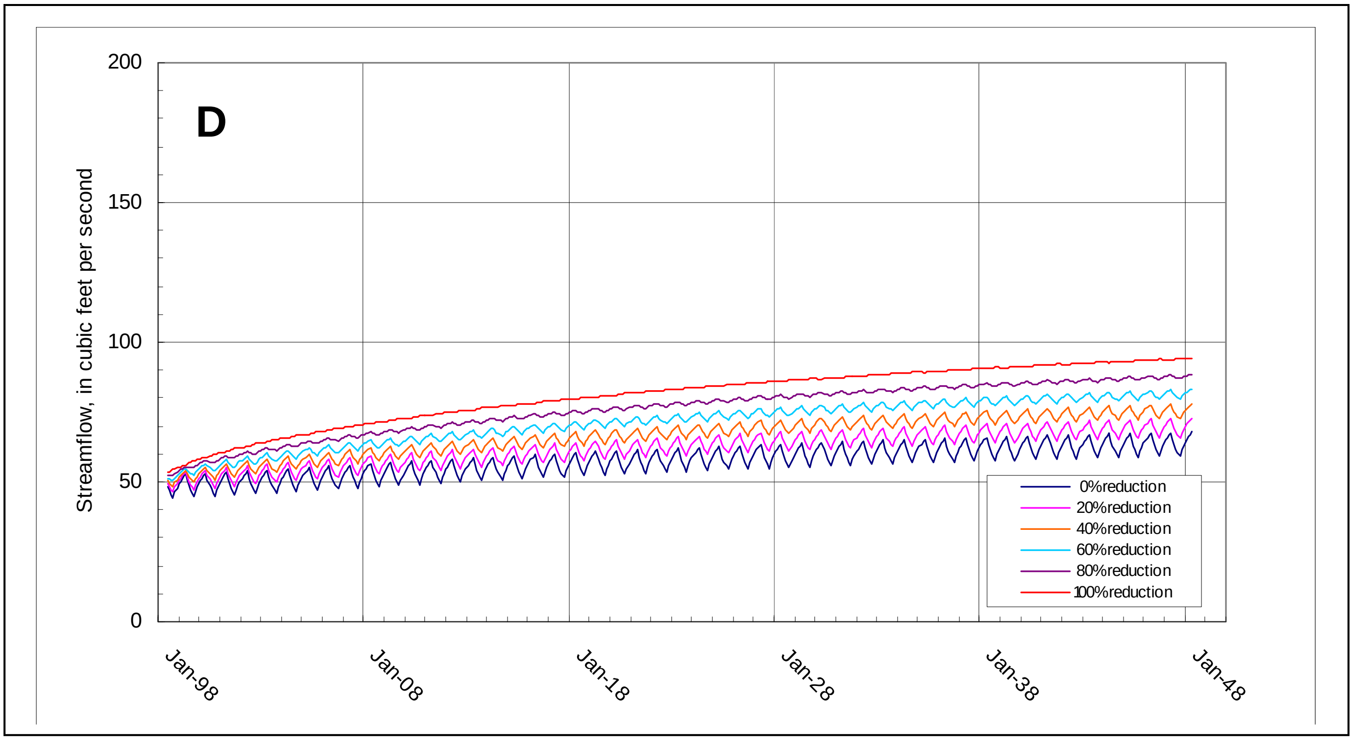
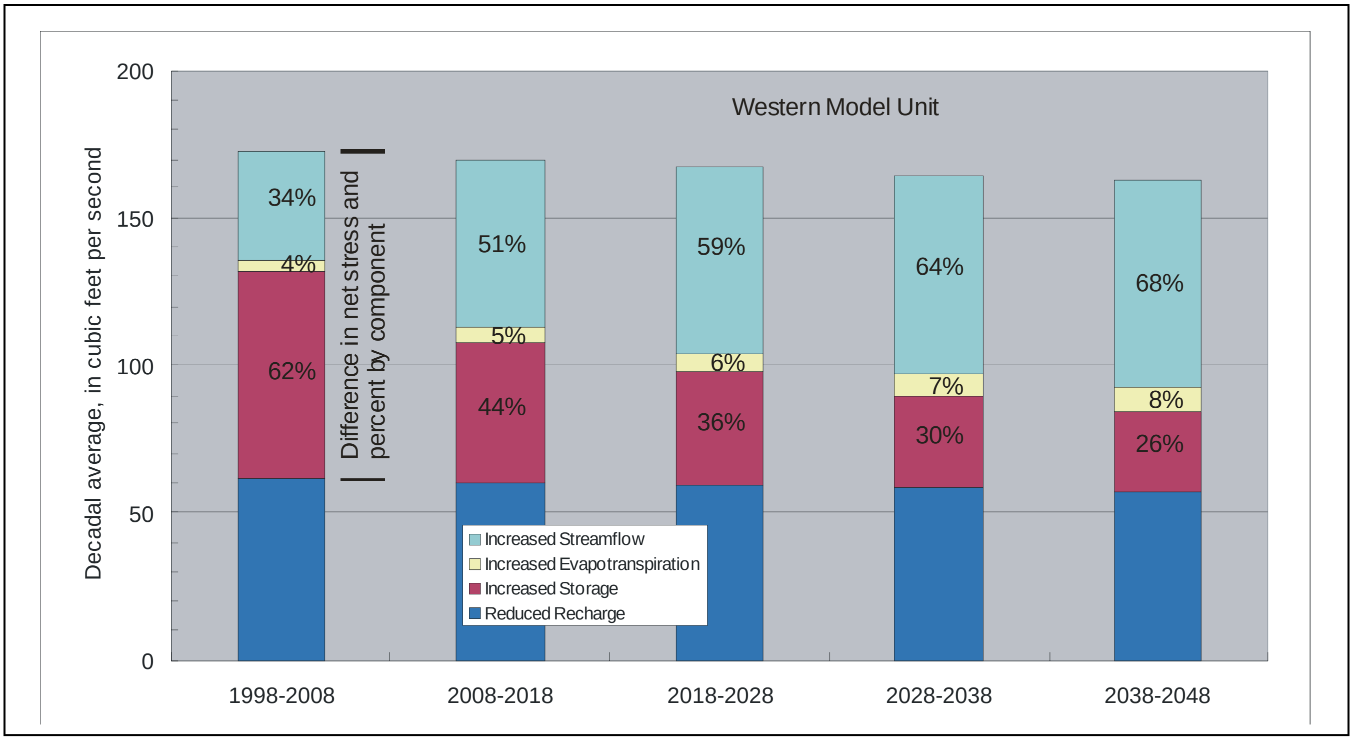


Figure 5 continued.



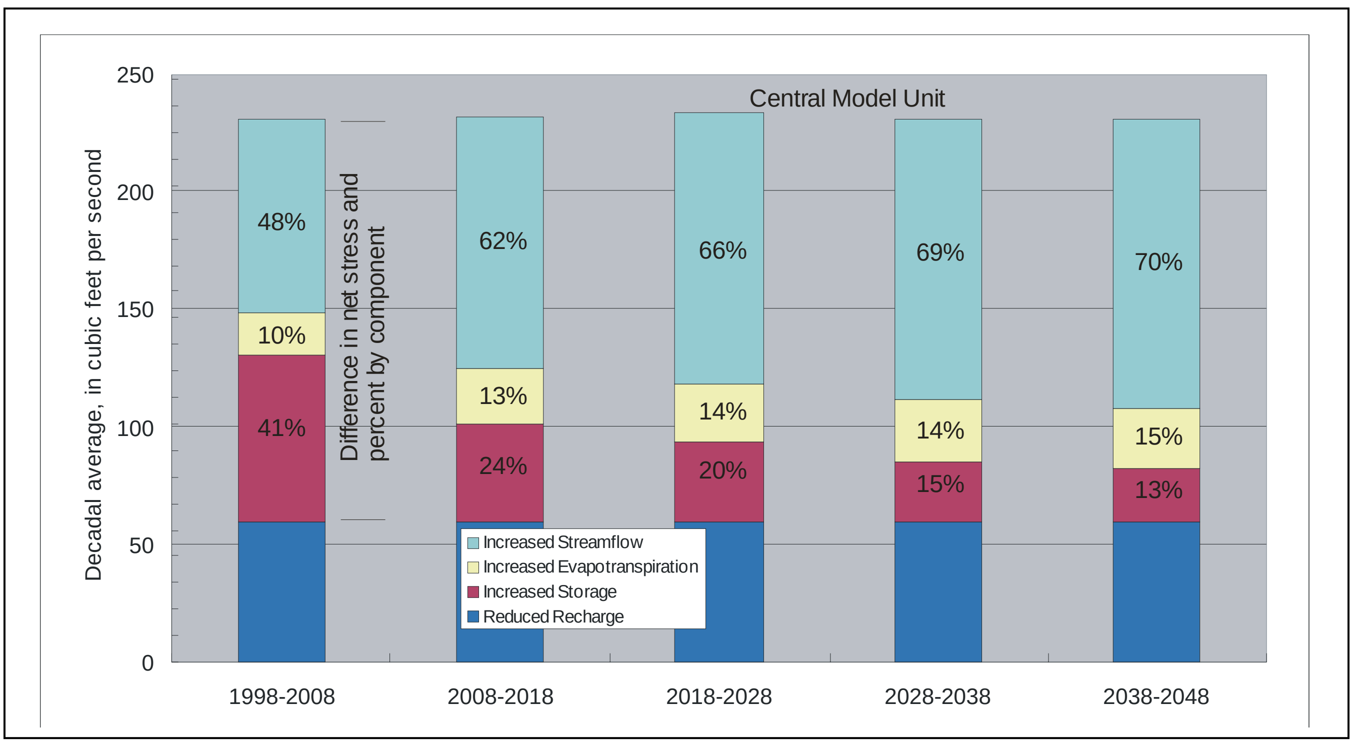


Figure 6. Differences between water budgets for the Pumping Effect and No Pumping Effect for the Hydrologically Connected Area of the Overappropriated Basin by model unit.

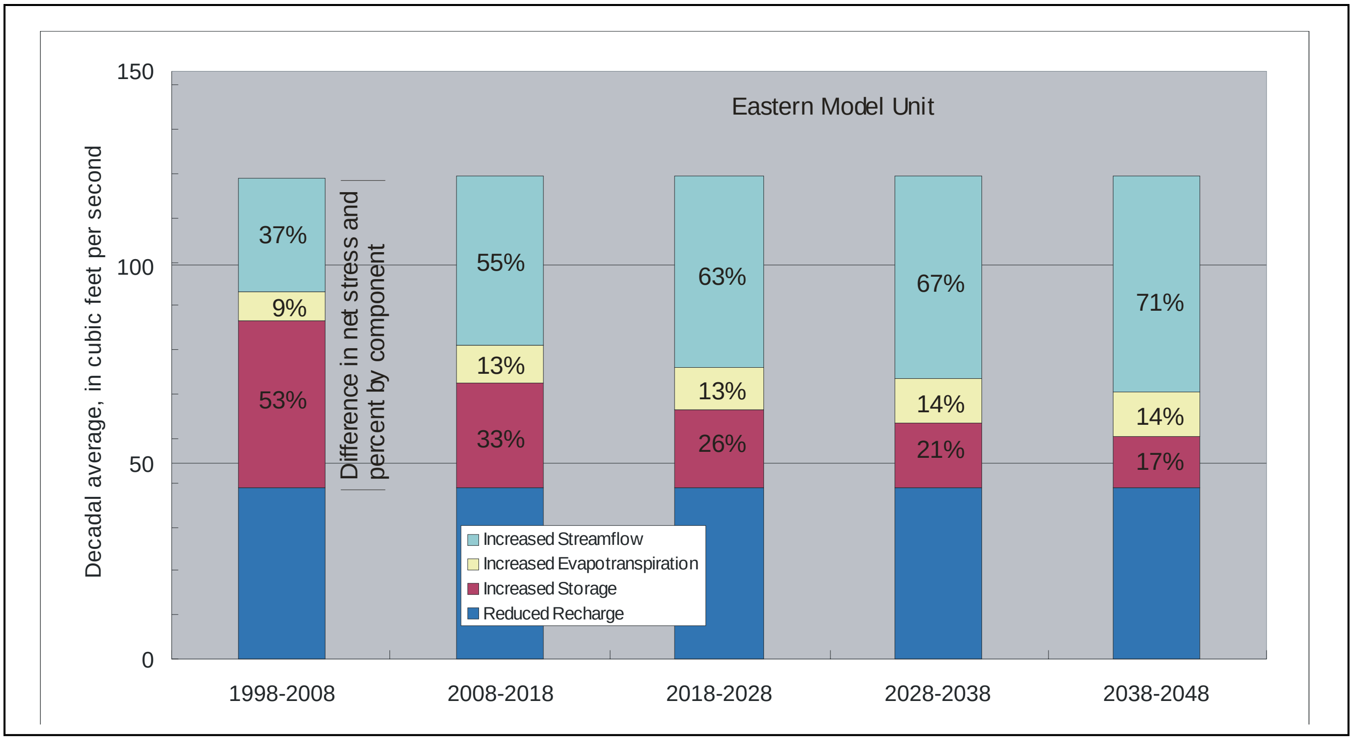


Figure 6 continued.