1. INTRODUCTION

1.1 Overview of COHYST 2010

The COoperative HYdrological Study (COHYST) is a multi-entity effort to address water supply issues within Nebraska through scientifically quantifiable methods that inform water managers and their decisions. COHYST is an ongoing effort since the 1990's and has had several phases to develop and improve hydrogeologic data, interpretations and models. COHYST 2010 is the latest development of the COHYST study of the Platte River drainage basin in central Nebraska.

Figure 1.1-1 is a map of the COHYST 2010 study area and model domain, which includes the Platte River drainage basin between Lewellen and Julesburg on the west and Duncan on the east, and which incorporates drainages north and south of the basin for the models to represent inter-basin relationships.

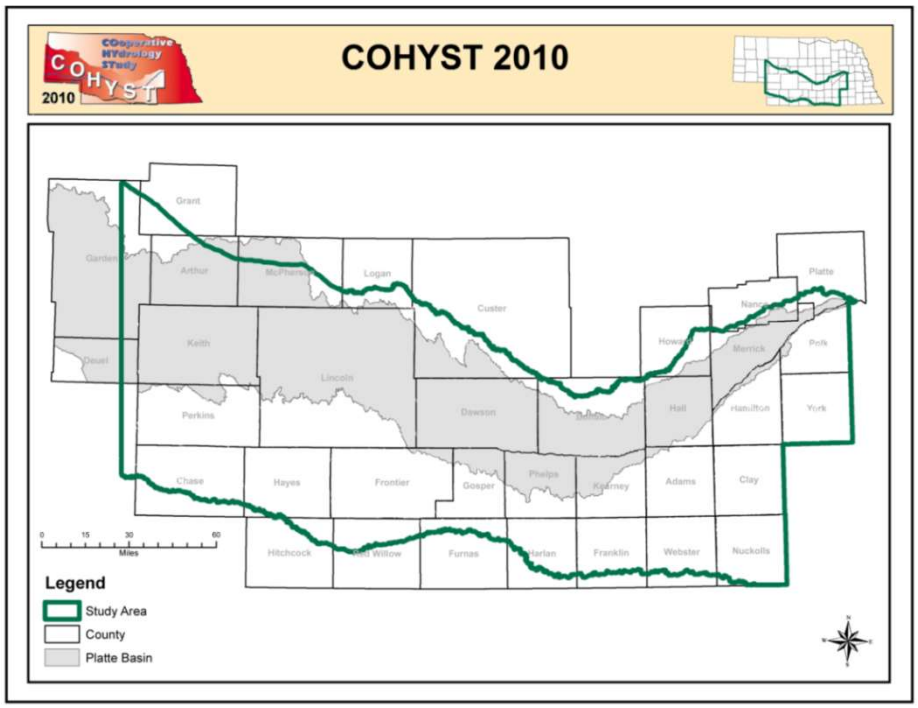

Figure 1.1-1. COHYST 2010 Study Area.

The Platte River Basin in Nebraska supplies surface and groundwater to agriculture, industries, domestic wells, and municipalities. Initial water management within the state separated the system into 2 separately managed systems, one that only considered surface water and the

other only considered groundwater. In highly developed hydrologically connected systems, this can lead to double-counting and subsequent over allocation of water supplies. Typical groundwater models cannot fully account for a large network of surface water diversions, and conversely surface water operations models cannot adequately account for surface water seepage and streamflow gains that occur through groundwater discharge to streams.

Therefore, a linked or integrated surface-groundwater model is necessary to capture the full range of water uses and impacts to the entire water budget in the Platte Basin, and to simulate and evaluate management scenarios. A third model, a watershed model that accounts for land-use, climate, and soil effects on the water budget, also is included in the modeling assemblage.

The specific components of the integrated COHYST model are the *watershed model* created by The Flatwater Group using outputs from the CROPSIM and FORTRAN code; the *surface water model* built by HDR Engineering using the STELLA software; and a *groundwater model* completed by Lee Wilson and Associates using the MODFLOW 2005 software.

The integration of these 3 models allows for water managers to explore how different management strategies would affect the entire water balance. For example, the integrated model can show how the conversion of surface water irrigated acres to groundwater irrigated acres impacts not only streamflows, but also calculate local recharge, impact to groundwater levels, and long-term accretions to streamflow. Model results are not intended for use in daily water operations but rather allow for useful comparisons of alternative futures.

The model documented in this report is updated and substantially modified from the model that was documented in the 2013 COHYST report. Documentation of the prior model is out-of-date as to model details, but provides background information on that can be consulted by those interested in the project goals, objectives and approach. Contact the Nebraska Department of Natural Resources for documentation and files regarding the 2013 model.

1.2 Participants in COHYST 2010

COHYST and COHYST 2010 are multi-entity collaborative efforts that rely upon group consensus regarding data collection, data interpretation, model development, calibration, model scenarios, and interpretation of results. The consensus-based modeling effort was to ensure that the model build was capable of modeling scenarios of interest to all vested parties. The COHYST 2010 model is sponsored by the following entities:

- Central Nebraska Public Power and Irrigation District (CNPPID), 2010 -2017.
- Central Platte Natural Resources District (CPNRD), 2010 -2017.
- Nebraska Public Power District (NPPD), 2010 -2017.
- Tri-Basin Natural Resources District (TBNRD), 2010 -2017.
- Twin Platte Natural Resources District (TBNRD), 2010 -2017.
- Nebraska Department of Natural Resources (NDNR, or DNR), 2010 – 2013.
- Nebraska Game and Parks Commission (NGPC), 2010-2013.

The project has been managed by Sponsor representatives who have met regularly and by a Technical Committee whose members were appointed by the Sponsors.

1.3 Report Outline

This report documents the COHYST 2010 models as calibrated in December 2016. The report outline is largely the same as used to document the 2013 integrated COHYST model. The modeling report contains 10 sections that include background information and data, development of each of the three separate hydrologic-based models, the model integration, model calibration, and current applications of the integrated COHYST 2010 model. Many components of the 2013 report have been carried over with few or no edits. The discussion of report chapters below emphasizes model changes since 2013.

Section 2, Section 3 and Section 4 of this report respectively describe the study area, provide an overview of model construction, and document the primary datasets. These sections have been updated, but are not fundamentally different from what was presented in 2013.

The CROPSIM-watershed model documented in Section 5 is a complete rework of the 2013 model. Water budgets are now calculated using actual monthly weather data, not averaged values, and from an increased number of climate stations. A more refined soil type map was used to better represent the actual soil variability across the model domain. The procedure for estimating runoff has been modified to produce results that better match observed data, and the municipal/industrial pumping dataset has been updated. The procedure for estimating irrigation pumping was validated by comparison to recent metered data.

The surface water model documented in Section 6 has been substantially revised to better simulate conditions during dry period, at the expense of a somewhat less good match during wet periods. This effort included substantial revisions to canal seepage estimates, an improved match to observed seasonality of irrigation demands and operating conditions in various areas, especially Sutherland Reservoir and Kearney Canal. A procedure for priority accounting is now included. Reservoir seepage is now simulated in the groundwater model.

The groundwater model documented in Section 7 has been substantially modified to reflect known hydrologic conditions and to correct prior errors. One of the largest changes to the model includes the characterization of the Platte River and its interaction with the underlying aquifer to ensure that the model can adequately model this interaction. There are now multiple river channels instead of a single channel, agricultural drains are included, and a revised simulation of riparian evapotranspiration. A new comparison data set for water levels concentrates data within the Platte River watershed. The model was recalibrated and re-optimized to produce new values of hydraulic conductivity and specific yield and a revised approach to simulation of recharge in areas of a deep water table.

The integrated model documented in Section 8 runs the three revised models individually with outputs from one model used as input to other models. Data transfers among the model can now be made using a Graphical User Interface rather than manually. Model outputs include on-farm water conditions, river flows and operations, well pumping, and changes to the surface and subsurface water budgets throughout the basin.

Section 9 provides an evaluation of the model, including a description of the calibration procedure and the results of test cases that were used to evaluate model functionality. Each submodel was calibrated based on data from 1985-2005 and further verified by consideration of outputs when the models are run using inputs from 2006-2010. Section 9 sets forth key assumptions made in construction of the models, and limitations on use of the model.

Section 10 documents some of the applications that have already been made of the model and provides suggestions on how to use (and not use) the model.

Conclusion. Based on its good calibration against historic data, the current models are considered to be reliable for their intended purposes. As with any model, COHYST 2010 is subject to further improvement as more data are obtained and as the attributes of the regional hydrology become better understood.