2019

Appendix A – Supplemental Technical Memos and Model Reports

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Components of the Current Robust Review Evaluation

A. Components analyzed in the current groundwater model evaluation

The 2019 Robust Review groundwater model evaluation was completed to provide a quantification of the NeDNR and NRDs management actions to meet the goals and objectives of the Integrated Management Plans in the Overappropriated Area of the Platte Basin. One piece of this evaluation was completed using groundwater models. The models included an estimate of changes in groundwater only irrigation use (via either landuse changes or metered use data), municipal use and industrial use, and certain management actions (recharge of excess flows via canals and recharge facilities, groundwater retirements, and streamflow augmentation). The processes for these activities are described in Section A of Appendix A. This current analysis replaces the previous analysis completed by Richard Luckey in 2008[1] which only included an evaluation of the changes in groundwater only irrigation use.

B. Components not analyzed in the current groundwater model evaluation

Livestock uses and the change in sandpits and small reservoirs were not evaluated within the groundwater models. Changes in the number of cattle since 1997 were evaluated by the NeDNR and the NRDs and the numbers have generally decreased over time, resulting in a net positive effect on water supplies in the Upper Platte Basin. Therefore, the determination was made that these uses did not need to be included in the groundwater model analysis. More details on the calculations of livestock numbers can be found in Section B.1 of Appendix A.

Sandpits and small reservoirs were previously analyzed by NeDNR in 2014. This analysis determined that the overall consumptive use of water from changes between 2010 and 2015 resulted in net decreases in consumptive use; consequently, resulting in a net positive effect on water supplies in the Upper Platte Basin. Therefore, the determination was made that no further analysis of this change was needed at this time. More details on the methodology for this analysis can be found in Section B.2 of Appendix A.

[1] Luckey, R.R. 2008. Estimated Stream Baseflow Depletion by Natural Resources District in the Nebraska Platte Basin due to Gained and Lost Groundwater Irrigated Land after July 1, 1997. *High Plains Hydrology, LLC*. https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/water-planning/upper-platte/publications/Estimated%20Stream%20Baseflow%20Depletion%20by%20Natural%20Resources%20District%20in%20the%20Nebraska%20Platte%20Basin%20.pdf

A.1 Cooperative Hydrology Study 2010 (COHYST2010) Groundwater Model Analysis Methods

A.1 Cooperative Hydrology Study 2010 (COHYST2010) Groundwater Model Analysis Methods

I. Objective

The purpose of this modeling evaluation is to simulate depletions to streamflow from development of groundwater-only irrigated lands in the Cooperative Hydrology Study 2010 (COHYST2010) model area from after 1997 through 2013, including groundwater acre retirements through 2023, and development of municipal and industrial (M&I) pumping after 1997 through 2013, and ongoing (1997 – 2063) offsets from management actions (excess flow recharge and augmentation) taken between 1997 and 2013.

The specific results that were summarized in the report are acres and crop type changes on groundwater-only irrigated land by Natural Resources District (NRD); M&I pumping changes by NRD; excess flow recharge volumes by project and contracting NRD; augmentation pumping by NRD; and the combined streamflow impacts of the aforementioned by NRD.

For each NRD analysis, two model runs are necessary: a baseline simulation and an impact/scenario simulation. The baseline simulation is the representation of the historical condition. The scenario simulation is the representation of constant 1997 groundwater only irrigated acres and M&I pumping. The difference between these two runs provides an estimate of the streamflow impacts from development and management actions after 1997.

The documented model that is the basis for this analysis consists of the Regionalized Soil Water Balance (Watershed model) and Groundwater portions of the COHYST2010 integrated model. Further documentation of the COHYST model is available at https://cohyst.nebraska.gov/, including datasets at https://cohyst.nebraska.gov/pdf/04-Datasets.pdf. Version 29 of the Watershed model and Version 28 of the Groundwater model were used. The simulation period for these analyses is 1950 to 2063. The Platte Basin Coalition (PBC) scope of work documents for the design of this analysis are available as attachments (Appendix A.1.1). Model files are available at https://UPJointPlanning.nebraska.gov.

II. Baseline Model Setup – Historical

A. Baseline Watershed Model Setup

The Flatwater Group, Inc. (TFG) was contracted by PBC to complete Watershed model runs for the Robust Review. The Watershed model used for the Robust Review was based on COHYST 2010 Watershed Model Run029, an updated version of the documented COHYST watershed model, as described in the TFG memorandum on the COHYST2010 Watershed Model Update – Run029, dated June 15, 2018 (Appendix A.1.2). For the Robust Review, COHYST Watershed Model Run029 was updated with irrigated acres and M&I pumping through 2013 and extended back to 1950 and forward to 2063. Information on the documented COHYST2010 M&I pumping is available at https://cohyst.nebraska.gov/pdf/appendix/04R-MunicipalProcessing.pdf. The Flatwater Group Memorandum on COHYST2010 area Model Runs dated November 26, 2018 (Appendix A.1.3) documents the Watershed model setup. Details on updates to M&I pumping and land use used in this analysis are available as Appendices A.1.4 and A.1.5, respectively.

Watershed results for the Robust Review were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel) MODFLOW groundwater model files.

B. Baseline Groundwater Model Setup

The groundwater model used for the Robust Review was based on the documented COHYST groundwater model updated with recharge and pumping files provided by the Watershed model update, as described in the previous section, and extended from 1950 to 2063. The following section describes changes made to the individual model files in setup of the Robust Review baseline model.

1. Pumping/.WEL

For the baseline run, the North Dry Creek augmentation pumping (NDC) was added to the Watershed output .WEL file. The pumping from the NDC augmentation well was obtained from a spreadsheet “NDC Augmentation Wells_SWLs.xls” tab “Aug Prod Well” provided by TBNRD. The NDC pumping data from the spreadsheet that are relevant to this analysis are provided as an attachment (Appendix A.1.6). The coordinates of the well (Lat: N40 38' 25.91700", Long: W99 06' 59.91771") were also obtained from this tab and were identified as model row-column 190-319. Only pumping through 2013 was used in this Robust Review. An email was exchanged with Nolan Little, TBNRD, on July 18, 2018, verifying these monthly pumped volumes:

Month	Year	Acre-Feet Pumped
7	2011	0.776667
10	2011	0.755833
6	2012	71.2375
7	2012	108.0308
8	2012	155.7767
9	2012	39.39333
5	2013	66.17667
6	2013	37.02333
7	2013	80.10083
8	2013	87.60417

2. Recharge

The documented COHYST2010 groundwater model is set up to take recharge arrays parameterized for seepage from surface water bodies (typically output data of the surface water model portion of the integrated COHYST2010 model) and recharge from precipitation and surface water irrigation and groundwater pumping (typically output data from the Watershed model).

The seepage values from canals and reservoirs are based on the surface water model portion of the Conservation Study. The Conservation Study reference documents can be found at https://UPJointPlanning.nebraska.gov. Seepage for 1950-2013 uses the values simulated from the Conservation Study baseline. Seepage for years 2014-2063 are represented by repeating 1989 to 2013 twice.

The excess flow canal and reservoir recharge was added to the historical surface water seepage recharge array. The excess flow recharge projects analyzed in this Robust Review are:

- Twin Platte excess flow canal recharge projects
- Central Platte excess flow canal recharge projects
- Phelps Canal excess flow recharge
- E65 Canal excess flow recharge
- Elwood excess flow recharge

The quantification of these projects are available in the memos on the Calculation of Excess Flows, Recharge Volumes and Percentages, and Discharge Volumes for Canal Recharge (Appendix A.1.7):

- From Margeaux Carter and Kari Burgert, NeDNR, to the POAC Technical Committee, dated March 15, 2018, revised June 12, 2018, revised June 7, 2019
- From Kari Burgert, NeDNR, to the POAC Technical Committee, dated June 14, 2018, revised October 11, 2018

For the second recharge array, the output from the baseline Watershed model run was used. The .RCH file from the Watershed output was reformatted into the array format by removing the time step header information.

All recharge multipliers used by the documented COHYST2010 groundwater model are set to 1.0.

3. Initial heads

The initial heads represented in the MODFLOW Basic package (.BAS) were changed to January 1950 levels created using pre-development groundwater level data and the methodology used to develop the starting heads for calibrated COHYST.

4. General head boundaries

There are four general head boundary arrays parameterized for the documented COHYST2010 groundwater model runs.

- The marginal heads developed for these runs are the same as calibrated.
- Lake McConaughy heads are based on the surface water model portion of the Conservation Study. Lake McConaughy heads for 1950-2013 use the end-of-month elevations from the Conservation Study. Lake McConaughy heads for years 2014-2063 are represented by repeating 1989 to 2013 twice.
- Hugh Butler Lake and Harry Strunk Lake heads for 1950-2013 use the end-of-month elevations from the U.S. Bureau of Reclamation (USBR) Hydromet database. Hugh Butler Lake and Harry Strunk Lake heads for years 2014-2063 are represented by repeating 1989 to 2013 twice.

5. Evapotranspiration

Phreatophyte evapotranspiration (EVT) represented in the .EVT package of the groundwater model is based on calibrated values. EVT values for 1985-2010 are calibrated values. Monthly 1950-1984 EVT are set to monthly 1985 values. Monthly 2011-2013 EVT are set to monthly 2010 values. To mimic the climate repetitions, 2014-2063 EVT are represented by repeating 1989 to 2013 twice.

6. Streams

The stream package in the integrated calibrated model of the latest version of COHYST2010 includes flows from inflows, diversions, returns, and watershed runoff. No diversions, returns, or watershed-modeled runoff are included in these simulations. Stress period inflows to the stream (90% of Sutherland reservoir seepage, inflow to the South Platte River at Julesburg, and inflow on the North Platte River below Keystone Dam) for 1950-2013 are taken from the surface water results of Conservation Study. Inflows for 2014-2063 are represented by repeating 1989 to 2013 values twice.

7. Drains

The documented model drain elevation and conductances were repeated for all periods.

8. Rivers

The documented model river stages, conductances, and elevations were repeated for all periods.

9. Baseline Groundwater Model Setup Summary

Pumping:	Watershed model to meet Net Irrigation Recharge (NIR) Historical M&I pumping North Dry Creek (NDC) pumping
Recharge:	
Watershed:	Watershed model
Surface water seepage:	1950-2013 from surface water model of Conservation Study 2014-2063 represented by repeating 1989 to 2013 twice Excess flow recharge
Multipliers:	No multipliers (multipliers of 1.0) were used for all zones
Initial heads:	Updated to January 1950 levels from previous NeDNR analysis
General head boundaries:	
Lake McConaughy:	1950-2013 from surface water model of Conservation Study 2014-2063 represented by repeating 1989 to 2013 twice
Hugh Butler & Harry Strunk:	1950-2013 from USBR Hydromet database 2014-2063 represented by repeating 1989 to 2013 twice
EVT:	1950-1984 represented by monthly 1985 values 1985-2010 from calibrated model 2011-2013 represented by monthly 2010 values 2014-2063 represented by repeating 1989 to 2013 twice
Streams:	Runoff, diversions, and returns are excluded for the entire period

Inflows:	1950-2013 from the surface water results of Conservation Study 2014-2063 represented by repeating 1989 to 2013 twice
Drains:	Documented values for all time periods
River:	Documented values for all time periods

III. Scenario Setup – Constant 1997 Conditions

The four scenarios for each of the three NRDs of Twin Platte NRD (TPNRD), Central Platte NRD (CPNRD), and Tri-Basin NRD (TBNRD) and the area outside of these three NRDs but part of the COHYST model area (Rest-of-Model Area) are to represent constant 1997 conditions as compared to the baseline that has historical groundwater-only irrigation and M&I conditions as well as management actions. This requires the scenario to be modified from the baseline both during the scenario watershed setup (land use and M&I pumping) and the scenario groundwater model setup (augmentation pumping and excess flow recharge). Only the recharge arrays and pumping volumes change between the baseline and scenario.

1. Scenario Watershed Model Setup

There was one run of the watershed model executed for the scenario simulation. The baseline inputs were modified by holding all groundwater-only irrigated acres and M&I pumping constant at 1997 levels through 2063. The Flatwater Group, Inc. Memorandum on COHYST2010 area Model Runs, (Appendix A.1.3) documents the Watershed model setup. The land use change and M&I pumping change was made for all areas of the model in a single watershed model run, and the resulting pumping and recharge impacts will be isolated by management area in the scenario groundwater model setup. The watershed results for the Constant-97 scenario were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel) MODFLOW groundwater model files.

2. Scenario Groundwater Model Setup

For each management area scenario, the scenario watershed model recharge and pumping values were used for the management area, and the baseline watershed model recharge and pumping values were used for the other NRDs and remainder of the model area. North Dry Creek pumping and excess flow recharge volumes were added to the scenarios for the management areas in which they did not occur (e.g., NDC pumping was added to TPNRD, CPNRD, and Rest-of-Model Area scenarios but not TBNRD scenario). All other groundwater model data are the same as in the baseline. The following table summarizes the four groundwater model runs for the Robust Review scenarios.

Table 1. Robust review scenarios representing constant 1997 conditions for comparison to the baseline scenario representing historical development and management actions.

Scenario Management Area	Scenario Description	Change to baseline well file	Change to baseline watershed recharge array	Change to baseline surface water seepage array
TPNRD	Historical without TPNRD GWO and M&I development after 1997 and without Twin Platte canals excess flow recharge	Constant97 scenario pumping in TPNRD	Constant97 scenario recharge in TPNRD	Does not include Twin Platte canals excess flow recharge
CPNRD	Historical without CPNRD GWO and M&I development after 1997 and without CPNRD and NPPD canals excess flow recharge	Constant97 scenario pumping in CPNRD	Constant97 scenario recharge in CPNRD	Does not include CPRND nor NPPD canals excess flow recharge
TBNRD	Historical without TBNRD GWO and M&I development after 1997, without NDC pumping, without E65 canals excess flow recharge	Constant97 scenario pumping in TBNRD and no NDC pumping	Constant97 scenario recharge in TBNRD	No change
Rest-of-Model Area	Historical without Rest-of-Model Area GWO and M&I development after 1997	Constant97 scenario pumping in Rest-of-Model	Constant97 scenario recharge in Rest-of-Model	No change

IV. Component Scenarios

The Post-1997 NRD impacts can be broken down further to determine the separate impacts of individual historical changes and management actions and the impacts from those in different management areas of an NRD. The individual component scenarios considered in the Robust Review are:

- Retired groundwater irrigated acres by NRD and hydrologically connected areas
- Change in groundwater-only irrigated acres after 1997 by NRD and hydrologically connected areas
- Change in groundwater-only irrigated acres and M&I pumping after 1997 by NRD and hydrologically connected areas (no management actions considered)
- North Dry Creek Augmentation Project pumping
- TPNRD-contracted excess flow recharge from 2011-2013
- CPNRD-contracted excess flow recharge from 2011-2013 , including separate analyses for:
    - The sum of Cozad, Orchard-Alfalfa, and Thirty-mile canals
    - The sum of Dawson County, Gothenburg, and Kearney canals
- TBNRD-contracted excess flow recharge individually:
    - E65 Canal in 2013
    - Elwood Reservoir from 2006-2013
    - Phelps Canal from 2011-2013

For the retired groundwater irrigated acres analysis, a scenario was developed with the Watershed model where the acres that were identified as retired from irrigation, were restored to groundwater irrigated. The watershed results for the unretired scenario (MOD001) were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel)

MODFLOW groundwater model files. The groundwater model scenario setup followed the same processes as identified in the last section.

For the remaining component scenarios, combinations of the historical and constant 1997 scenario recharge and well values were used to create scenarios in which the component of interest was removed from the historical scenario. The M&I pumping is an auxiliary term to the watershed modeled pumping. The Flatwater Group, Inc. provided a Constant-97 pumping file that included historical M&I development, i.e., only 1997 groundwater-only irrigated acres were held constant, which will be referred to as Constant97HistMI. The groundwater model scenario setup followed the same processes as identified in the last section, unless otherwise described in the following table.

Table 2. Robust review component scenarios representing individual historical changes and management actions in differing management areas for comparison to the baseline scenario representing historical development and management actions.

Scenario Run	Change to baseline well file	Change to baseline watershed recharge array	Change to baseline surface water seepage array
1. Historical without TPNRD retired lands	MOD001 well values in TPNRD	MOD001 recharge values in TPNRD	no change
2. Historical without TPNRD OA area retired lands	MOD001 well values in TPNRD OA	MOD001 recharge values in TPNRD OA	no change
3. Historical without CPNRD retired lands	MOD001 well values in CPNRD	MOD001 recharge values in CPNRD	no change
4. Historical without CPNRD OA area retired lands	MOD001 well values in CPNRD OA	MOD001 recharge values in CPNRD OA	no change
5. Historical without CPNRD HC area retired lands	MOD001 well values in CPNRD HC	MOD001 recharge values in CPNRD HC	no change
6. Historical without TBNRD retired lands	MOD001 well values in TBNRD	MOD001 recharge values in TBNRD	no change
7. Historical without TBNRD OA area retired lands	MOD001 well values in TBNRD OA	MOD001 recharge values in TBNRD OA	no change
8. Historical without TBNRD HC area retired lands	MOD001 well values in TBNRD HC	MOD001 recharge values in TBNRD HC	no change
9. Historical without TPNRD GWO development after 1997	Constant97HistMI well values in TPNRD	Constant97 recharge values in TPNRD	no change
10. Historical without TPNRD OA area GWO development after 1997	Constant97HistMI well values in TPNRD OA	Constant97 recharge values in TPNRD OA	no change
11. Historical without CPNRD GWO development after 1997	Constant97HistMI well values in CPNRD	Constant97 recharge values in CPNRD	no change
12. Historical without CPNRD OA area GWO development after 1997	Constant97HistMI well values in CPNRD OA	Constant97 recharge values in CPNRD OA	no change

Scenario Run	Change to baseline well file	Change to baseline watershed recharge array	Change to baseline surface water seepage array
13. Historical without CPNRD HC area GWO development after 1997	Constant97HistMI well values in CPNRD HC	Constant97 recharge values in CPNRD HC	no change
14. Historical without TBNRD GWO development after 1997	Constant97HistMI well values in TBNRD	Constant97 recharge values in TBNRD	no change
15. Historical without TBNRD OA area GWO development after 1997	Constant97HistMI well values in TBNRD OA	Constant97 recharge values in TBNRD OA	no change
16. Historical without TBNRD HC area GWO development after 1997	Constant97HistMI well values in TBNRD HC	Constant97 recharge values in TBNRD HC	no change
17. Historical without TPNRD GWO and M&I development after 1997	Constant97 well values in TPNRD	Constant97 recharge values in TPNRD	no change
18. Historical without TPNRD OA area GWO and M&I development after 1997	Constant97 well values in TPNRD OA	Constant97 recharge values in TPNRD OA	no change
19. Historical without CPNRD GWO and M&I development after 1997	Constant97 well values in CPNRD	Constant97 recharge values in CPNRD	no change
20. Historical without CPNRD OA area GWO and M&I development after 1997	Constant97 well values in CPNRD OA	Constant97 recharge values in CPNRD OA	no change
21. Historical without CPNRD HC area GWO and M&I development after 1997	Constant97 well values in CPNRD HC	Constant97 recharge values in CPNRD HC	no change
22. Historical without TBNRD GWO and M&I development after 1997	Constant97 well values in TBNRD	Constant97 recharge values in TBNRD	no change
23. Historical without TBNRD OA area GWO and M&I development after 1997	Constant97 well values in TBNRD OA	Constant97 recharge values in TBNRD OA	no change
24. Historical without TBNRD HC area GWO and M&I development after 1997	Constant97 well values in TBNRD HC	Constant97 recharge values in TBNRD HC	no change
25. Historical without North Dry Creek augmentation pumping	No NDC pumping; Baseline well file from the Watershed model	no change	no change
26. Historical without Twin Platte canals excess flow recharge	no change	no change	Does not include Twin Platte canals excess flow recharge

Scenario Run	Change to baseline well file	Change to baseline watershed recharge array	Change to baseline surface water seepage array
27. Historical without Phelps Canal excess flow recharge	no change	no change	Does not include Phelps Canal excess flow recharge
28. Historical without E65 Canal excess flow recharge	no change	no change	Does not include E65 Canal excess flow recharge
29. Historical without Elwood Reservoir excess flow recharge	no change	no change	Does not include Elwood Reservoir excess flow recharge
30. Historical without CPNRD canals excess flow recharge	no change	no change	Does not include CPRND canals excess flow recharge
31. Historical without NPPD canals excess flow recharge	no change	no change	Does not include NPPD canals excess flow recharge

V. Model Output and Post-processing

1. Watershed Model Outputs

The Watershed land use and water balance summaries were used to generate the summaries of acres by irrigation type and crop type. The accounting points and NRD area zone files described later in the groundwater model output post-processing were used to create these reports. The following differences in the annual number of acres by irrigation source or crop type were used:

Post-97 developed acres = Historical/Baseline acres – Constant97cenario acres
Retired acres = Historical/Baseline acres – Unretired/MOD001 acres

The land use and water balance summaries were also used to QA/QC the pumping and recharge differences that were calculated in groundwater model post-processing.

2. Groundwater Model Outputs

a. Process model results by NRD zone

The cell-by-cell outputs of the groundwater model runs were processed through ZoneBudget with a zone file representing the management areas, detailed in the following Zone files section. The difference between the pumping and recharge between the scenario and the baseline were summarized annually and compared to the watershed model outputs for QA/QC.

b. Process model results by accounting zone

The cell-by-cell output of the groundwater model was run through ZoneBudget with a zone file representing the delineations of the stream accounting points. For the purpose of the report, the zones were combined to account for the North Platte River, South Platte River, Platte River Upstream of Elm Creek, and Platte River from Elm Creek to Chapman, as further detailed in the Zone files section. The stream leakage terms from the ZoneBudget outputs are summarized on an annual basis. Net stream leakage is calculated as the difference between the volumes of water that went from the aquifer to the stream and from the stream to the aquifer. The difference between the scenario and baseline net stream leakage are the scenario impacts. As calculated, negative impacts are depletions and positive impacts are accretions.

c. Adjustments for management activities

In order to account for the total impact to streamflow the Constant97 impacts needed to be adjusted for the following:

- TPNRD
    - The addition of streamflow from the Western Canal excess flow recharge volumes modeled with the WWUM model and shared with SPNRD on the South Platte River.
- CPNRD
    - The reduction in accretions from the CPNRD excess flow events that were purchased by Platte River Recovery Implementation Program (PRRIP).
- TBNRD
    - The addition of streamflow from the North Dry Creek augmentation between Elm Creek and Chapman.
    - Addition of accretions from the Elwood Reservoir, E65 Canal, and Phelps Canal excess flow events that are attributed to TBNRD.

The entirety of the Western Canal recharge project areas (the canal and recharge pits) are covered by the WWUM model. Therefore, that model was used to determine the accretions associated with Western Canal recharge. TPNRD and SPNRD contracted a 70%/30% split on the Western Canal recharge events from 2011-2013. For the Robust Review, the entire volume of recharge was applied to the WWUM model, and the accretions were split 70%/30%. The accretions occurred on the South Platte River and were added to the TPNRD impacts to that zone.

CPNRD impacts were discounted for accretions from 2011-2013 excess flow recharge events from CPNRD canals, Cozad, Orchard-Alfalfa, and Thirty-Mile that were purchased by PRRIP through 2018. The separate model run that subtracted only the excess flow recharge events on these canals from the baseline was completed, and accretions were calculated as described previously. The accretions purchased by PRRIP were discounted from CPNRD impacts annually from the Platte River Upstream of Elm and Platte River from Elm Creek to Chapman accounting zones in the same annual proportions that they occurred.

North Dry Creek enters the Platte River south of Kearney. All of the augmentation was added to the TBNRD impacts for the accounting zone Platte River from Elm Creek to Chapman.

The 2011-2013 Phelps Canal excess flow recharge events were contracted 50%/50% between the TBNRD and PRRIP. For this reason, half of the accretions resulting from these recharge events belong to the PRRIP and half belong to the TBNRD. To separate the accretions between PRRIP and TBNRD, first, an impact model run was completed by subtracting 100% of the excess flow recharge events on Phelps Canal from the baseline with 100% of the accretions being calculated from this change. Then, fifty percent of the 2011-2013 Phelps Canal excess flow recharge accretions were included in the TBNRD impacts.

Elwood Reservoir and E65 excess flow events were included in both the baseline and Constant97 TBNRD runs. The separate model runs that subtracted only the excess flow recharge events on these areas from the baseline were completed, and accretions were calculated as described previously and were added to the TBNRD impacts.

d. Streamflow Impact trend and uncertainty

The streamflow impacts for the period 2014-2063 are modeled based on assumptions of a representative climate without additional management actions or changes in land use incorporated after 2013. A linear fit is applied to the modeled depletions 2014-2063 to illustrate the 50-year trend. The inter-annual variability of modeled streamflow impacts for 2014-2063 is shown as a band of the maximum residual, or difference between the modeled data and trend. The modeled streamflow impacts are not exactly periodic about the trend despite having explicit period climate inputs and constant land use. This result is primarily due to the inclusion of all management actions in the analysis prior to 2013 and discontinuing many of those management actions in the future projection (2014-2063).

3. Zone Files

For the COHYST model, one zone file delineated the model area into accounting points: 1) North Platte River; 2) South Platte River; 3) Platte River between the North Platte and South Platte confluence and Elm Creek; 4) Platte River between Elm Creek and Chapman; 5) Below Chapman; and 6) Elsewhere. The file was developed by assigning attributes to model grid cells using ArcGIS spatial join by centroid to HUC10 basins, with some small adjustments to match the COHYST stream cell locations. For comparison to the Luckey (2006) report, the model grid cell assigned to the Tri-County diversion is the cell identified by the confluence in the HUC10 dataset, although geographically Tri-County is downstream of the confluence. The confluence through Chapman accounting zones based on the HUC10 were visually inspected and adjusted by individual grid cells to better reflect the model stream cell locations and accepted National Hydrography Dataset (NHD) flow lines.

The second zone file delineated the model file into management areas: 1. CPNRD; 2. CPNRD HC; 3. CPNRD OA; 4. TBNRD; 5. TBNRD HC; 6. TBNRD OA; 7. TPNRD; 8. TPNRD OA; 9. LBNRD; 10. LBNRD HC; 11. UBBNRD; 12. UBBNRD HC; 13. other NRD; 14. other HC; 15. NPNRD and SPNRD. Regions are defined as inside or outside the relevant NRDs, and then inside or outside the over-appropriated or hydrologically connected (28/40) management areas. For the purpose of the total impacts for each NRD and the rest-of-model area, the following zones were combined as: TPNRD = zones 7 and 8; CPNRD = zones 1, 2, and 3; TBNRD = zones 4, 5, and 6; Rest-of-Model area = zones 9, 10, 11, 12, 13, and 14. The management areas zone file was developed by assigning attributes to model grid cells using ArcGIS spatial join by centroid to NRDs, the Platte Basin Over-Appropriated Area, HUC10, and section polygons, and by direct transfer of calculated SDF values using the results from the model run beginning in 1950 and conducted in June 2018. NRDs and the Over-Appropriated Area are explicitly defined as the regions encapsulated in the spatial join. The hydrologically connected (28/40) region was defined as the cells with SDF greater than or equal to 0.28, within the Platte Basin, following the HUC10 basin boundary, and east of the Over-Appropriated Area. Because the Over-Appropriated Area and newly developed hydrologically connected area are offset North-to-South at their intersection, the southern hydrologically connected boundary was extended, and the northern extent reduced to smooth the boundary. Additionally, the Upper Big Blue NRD Over-Appropriated Management Area, which is defined by section in their IMP, was explicitly classified based on the join by centroid of the model cells within UBBNRD and the IMP sections. The Little Blue NRD Over-Appropriated Management Area, which has not been agreed upon in an IMP but will likely be defined by quarter sections, was explicitly classified in a similar manner, as cells in LBNRD with centers in quarter sections which fall within the Platte Basin and have an SDF of at least 0.28.

VI. Results

The acres changes, pumping and recharge differences, and resulting differences in stream leakage are summarized in four spreadsheets – one for each NRD/area. These spreadsheets are available at https://UPJointPlanning.nebraska.gov.

VII. Additional/Further Investigations

The results of this analysis are subject to the limitations of the modeling processes outlined in this documentation. Further investigations may be necessary to test the assumptions of this analysis and to assess the impacts of other management actions. Below is a short list of recommended further investigations:

- The sensitivity of annual depletions resulting from different climate representations
- The sensitivity of depletions to different crop type conversions on groundwater-only irrigated acres historically and when converting between groundwater only to dryland
- The sensitivity of annual and accounting point depletions to including runoff and diversions and returns
- Updating conservation practices/more accurate representation of current farming practices
- Hydraulic conductivity and initial head sensitivity in the vicinity of Plum Creek

This documentation describes the updates, modifications, and methods used by NeDNR to conduct the specific model simulations associated with the robust review evaluation for the COHYST model area.

A.1 Western Water Use Management (WWUM) Model Groundwater Model Analysis Methods

A.1 Western Water Use Management (WWUM) Model Groundwater Model Analysis Methods

I. Objective

The purpose of this modeling evaluation is to simulate depletions to streamflow from development of groundwater-only irrigated lands and municipal and industrial (M&I) pumping in North Platte Natural Resources District (NPNRD) and South Platte Natural Resources District (SPNRD) after 1997 through 2013, including impacts from groundwater acre retirements, allocated uses starting in 2009, and excess flow recharge. The specific results summarized in the Robust Review report are acres and crop type changes on groundwater-only irrigated land by NRD; M&I pumping changes by NRD; excess flow recharge volumes by project and contracting NRD; and the combined streamflow impacts of the aforementioned by NRD.

For each NRD analysis, two model runs are necessary: a baseline simulation and an impact/scenario simulation. The baseline simulation is the representation of the historical condition including metered irrigation pumping. The scenario simulation is the representation of constant 1997 groundwater only irrigated acres and M&I pumping. The difference between these two runs provides an estimate of the streamflow impacts from development and management actions after 1997.

The documented model that is the basis for this analysis consists of the Regionalized Soil Water Balance (Watershed model) and Groundwater portions of the WWUM model, available at http://www.spnrd.org/Html/WWUM.html. Version 28 of the Watershed model and the 1953 to 2013 update of the Groundwater model were used. The simulation period for these analyses is May 1953 to 2063. The Platte Basin Coalition scope of work documents for the design of this analysis are available as attachments (Appendix A.1.1). Model files are available at https://UPJointPlanning.nebraska.gov.

II. Baseline Model Setup – Historical

A. Baseline Watershed Model Setup

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Coalition (PBC) to complete Watershed model runs for the Robust Review. The Watershed model used for the Robust Review was based on the calibrated WWUM Watershed Model Run028 extended forward to 2063. The Flatwater Group, Inc. Memorandum on October 2018 Update: Post 97 Analysis WWUMM , dated October 11, 2018, (Appendix A.1.8) documents the Watershed model setup. Details on updates to M&I pumping and land use used in this analysis are available as Appendix A.1.9 and A.1.10, respectively.

Watershed results for the Robust Review were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel) MODFLOW groundwater model files.

B. Baseline Groundwater Model Setup

The groundwater model used for the Robust Review was based on the documented WWUM groundwater model updated with recharge and pumping files provided by the Watershed model update, as described in the previous section, and extended to 2063. The following section describe changes made to the individual model files in setup of the Robust Review baseline model.

1. Pumping/.WEL

For the baseline run, the pumping file from the Watershed model that allowed historical development of groundwater only irrigated acres and metered pumping and M&I pumping was used. No additional modifications were made.

2. Recharge

Excess flow recharge was added to the historical recharge file provided by The Flatwater Group, Inc. Adaptive Resources, Inc. (ARI) provided NeDNR with the rates and cell locations of excess flow recharge to include in the analysis in the file *rr_excess_flow_11092018.csv*, available at https://UPJointPlanning.nebraska.gov. The excess flow recharge projects analyzed in this Robust Review are:

- Western Canal and pits excess flow recharge
- North Platte canals excess flow recharge, includes the canals of: Belmont, Castle Rock, Central, Chimney Rock, Enterprise, Farmers, Lisco, Nine Mile, Minatare, Pathfinder and Winters Creek.

The quantification of these projects are available in:

- A memorandum on NPNRD and SPNRD Canal Excess Flow Diversion, Recharge Analysis Comparison, and Canal Loss Recommendation from Thad Kuntz, P.G., Joe Reedy G.I.T., and Jason Yuill to John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition, dated March 10, 2017 (Appendix A.1.11)
- A zipped file of Western canal excess flow data available at https://UPJointPlanning.nebraska.gov.

3. General head boundaries

The last 12 months of the calibrated model general head boundaries were repeated 51 times to extend the model to 2063.

4. Evapotranspiration

Phreatophyte evapotranspiration (EVT) represented in the .EVT package of the groundwater model is based on calibrated values. The last 12 months of the calibrated model EVT rates were repeated 51 times to extend the model to 2063.

5. Streams

The last 12 months of the calibrated model streamflows were repeated 51 times to extend the model to 2063.

6. Drains

The last 12 months of the calibrated model drain flows were repeated 51 times to extend the model to 2063.

7. Baseline Groundwater Model Setup Summary

Pumping: Watershed model, metered pumping and 5-year climate repeat Historical M&I pumping

Recharge:	Watershed model, calibrated surface water model seepage values modified by ARI and supplied as ancillary to Watershed model output, excess flow recharge
Initial heads:	No change from calibrated
General head boundaries:	
May 1953-2013:	Calibrated
2013- Dec. 2063:	Last 12 months of calibrated
Streamflows:	
May 1953-2013:	Calibrated
2013- Dec. 2063:	Last 12 months of calibrated
Drains:	
May 1953-2013:	Calibrated
2013- Dec. 2063:	Last 12 months of calibrated

III. Scenario Setup – Constant 1997 Conditions

One scenario for each of NPNRD and SPNRD represent constant 1997 conditions as compared to the baseline that has historical groundwater-only irrigation and M&I conditions as well as management actions. This requires the scenario to be modified from the baseline both during the scenario watershed setup (land use and M&I pumping) and the scenario groundwater model setup (excess flow recharge). Only the recharge and pumping volumes change between the baseline and scenario.

1. Scenario Watershed Model Setup

There was one run of the watershed model executed for the scenario simulation. The baseline inputs were modified by holding all groundwater-only irrigated acres and M&I pumping constant at 1997 levels through 2063. The Flatwater Group, Inc. Memorandum on October 2018 Update: Post 97 Analysis (Appendix A.1.8) dated October 11, 2018, documents the Watershed model setup. The land use change and M&I pumping change were made for SPNRD and NPNRD in a single watershed model run, and the resulting pumping and recharge impacts will be isolated by management area in the scenario groundwater model setup. The watershed results for the Constant-97 scenario were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel) MODFLOW groundwater model files.

2. Scenario Groundwater Model Setup

For each management area scenario run, the scenario watershed model recharge and pumping values were used for the management area, and the baseline watershed model recharge and pumping values were used for the other NRDs and remainder of the model area. Due to potential discrepancies in how commingled acres were handled in the land use files used in the Watershed model, baseline values were used for the Western Canal Service Area for all scenarios. Excess flow recharge volumes were added to the scenarios for the management areas in which they did not occur. All other groundwater model data are the same as in the baseline. The following table summarizes the two groundwater model runs for the Robust Review scenarios.

Table 1. Robust review scenarios representing constant 1997 conditions for comparison to the baseline scenario representing historical development and management actions.

Scenario Management Area	**Scenario Description**	**Change to baseline well file**	**Change to baseline recharge file**
NPNRD	Historical without NPNRD GWO and M&I development after 1997 and without North Platte canals excess flow recharge	Constant97 scenario pumping in NPNRD	- Constant97 scenario recharge in NPNRD - Does not include North Platte canals excess flow recharge
SPNRD	Historical without CPNRD GWO and M&I development after 1997	Constant-97 scenario pumping in SPNRD, except in the Western Canal Service Area	Constant97 scenario recharge in SPNRD, except in the Western Canal Service Area

IV. Component Scenarios

The Post-1997 NRD impacts can be broken down further to determine the separate impacts of individual historical changes and management actions and the impacts from those in different management areas of an NRD. The individual component scenarios considered in the Robust Review are:

- Change in groundwater-only irrigated acres after 1997 by NRD and OA areas
- Change in groundwater-only irrigated acres and M&I pumping after 1997 by NRD and OA areas (no management actions considered)
- NPNRD-contracted excess flow recharge from 2011-2013
- Western Canal and pits excess flow recharge from 2011-2013

Combinations of the historical and constant 1997 scenario recharge and well values were used to create scenarios in which the component of interest was removed from the historical scenario. The M&I pumping is an auxiliary term to the watershed modeled pumping. The Flatwater Group, Inc. provided a Constant-97 pumping file that included historical M&I development, i.e., only 1997 groundwater-only irrigated acres were held constant, which will be referred to as Constant97HistMI. The groundwater model scenario setup followed the same processes as identified in the last section, unless otherwise described in the following table.

Table 2. Robust review component scenarios representing individual historical changes and management actions in differing management areas for comparison to the baseline scenario representing historical development and management actions.

Scenario Run	Change to baseline well file	Change to baseline recharge file
32. Historical without NPNRD GWO development after 1997	Constant97HistMI well values in NPNRD	Constant97 recharge values in NPNRD
33. Historical without NPNRD OA area GWO development after 1997	Constant97HistMI well values in NPNRD OA	Constant97 recharge values in NPNRD OA
34. Historical without SPNRD GWO development after 1997	Constant97HistMI well values in SPNRD except in the Western Canal Service Area	Constant97 recharge values in SPNRD except in the Western Canal Service Area
35. Historical without SPNRD OA area GWO development after 1997	Constant97HistMI well values in SPNRD OA except in the Western Canal Service Area	Constant97 recharge values in SPNRD OA except in the Western Canal Service Area
36. Historical without NPNRD GWO and M&I development after 1997	Constant97 well values in NPNRD	Constant97 recharge values in NPNRD
37. Historical without NPNRD OA area GWO and M&I development after 1997	Constant97 well values in NPNRD OA	Constant97 recharge values in NPNRD OA
38. Historical without SPNRD GWO and M&I development after 1997	Constant97 well values in SPNRD except in the Western Canal Service Area	Constant97 recharge values in SPNRD except in the Western Canal Service Area
39. Historical without SPNRD OA area GWO and M&I development after 1997	Constant97 well values in SPNRD OA except in the Western Canal Service Area	Constant97 recharge values in SPNRD OA except in the Western Canal Service Area
40. Historical without North Platte canals excess flow recharge	no change	Does not included North Platte canals excess flow recharge

Scenario Run	Change to baseline well file	Change to baseline recharge file
41. Historical without Western Canal and pits excess flow recharge	no change	Does not include Western Canal and pits excess flow recharge

V. Model Output and Post-processing

1. Watershed Model Outputs

The Watershed land use and water balance summaries were used to generate the summaries of acres by irrigation type and crop type. The NRD area zone files described later in the groundwater model output post-processing were used to create these reports. The following differences in the annual number of acres by irrigation source or crop type were used:

Post-97 developed acres = Historical/Baseline acres – Constant97scenario acres

The land use and water balance summaries were also used to QA/QC the pumping and recharge differences that were calculated in groundwater model post-processing.

2. Groundwater Model Outputs

a. Process model results by NRD zone

The cell-by-cell outputs of the groundwater model runs were processed through zonebudget with a zone file representing the management areas, detailed in the following Zone files section. The difference between the pumping and recharge between the scenario and the baseline were summarized annually and compared to the watershed model outputs for QA/QC.

b. Process model results by accounting zone

The cell-by-cell output of the groundwater model was run through ZoneBudget with a zone file representing the delineations of the stream accounting points. For the purpose of the report, the zones were combined to account for the North Platte River, South Platte River, and Lodgepole Creek, as further detailed in the Zone files section. The stream leakage terms from the ZoneBudget outputs are summarized on an annual basis. Net stream leakage is calculated as the difference between the volumes of water that went from the aquifer to the stream and from the stream to the aquifer. The difference between the scenario and baseline net stream leakage are the scenario impacts. As calculated, negative impacts are depletions and positive impacts are accretions.

c. Adjustments for management activities

In order to account for the total impact to streamflow the SPNRD Constant97 impacts needed to be adjusted for the portion of the Western Canal and pit accretions that were attributed to SPNRD contract.

The entirety of the Western Canal recharge project areas (the canal and recharge pits) are covered by the WWUM model. Therefore, this model was used to determine the accretions associated with Western Canal and pit recharge. TPNRD and SPNRD contracted a 70%/30% split on the Western Canal recharge events from 2011-2013. For the Robust Review, the entire volume of recharge was applied to the WWUM model, and the accretions were split 70%/30%. The accretions occurred on the South Platte River and were added to the SPNRD impacts to that zone.

d. Impacts trend and uncertainty

The streamflow impacts for the period 2014-2063 are modeled based on assumptions of a representative climate without additional management actions or changes in land use incorporated after 2013. A linear fit is applied to the modeled depletions 2014-2063 to illustrate the 50-year trend. The inter-annual variability of modeled streamflow impacts for 2014-2063 is shown as a band of the maximum residual, or difference between the modeled data and trend. The modeled streamflow impacts are not exactly periodic about the trend despite having explicit period climate inputs and constant land use. This result is primarily due to the inclusion of all management actions in the analysis prior to 2013 and discontinuing many of those management actions in the future projection (2014-2063).

3. Zone Files

For the WWUM model, one zone file delineated the model area into accounting points: 1) Out of Basin; 2) Out of State, North Platte River; 3) In State, North Platte River; 4) Out of State, Lodgepole Creek; 5) In State, Lodgepole Creek; 6) Out of State, South Platte River; and 7) In State, South Platte River. The file was developed by assigning attributes to model grid cells using ArcGIS spatial join by centroid to HUC10 basins

The second zone file delineated the model file into management areas: 1. Within Nebraska, not including NPRND or SPNRD; 2. TPNRD OA; 3. NPNRD; 4. NPNRD OA; 5. SPNRD; 6. SPNRD OA; 7. Western Canal Service Area; and 8. Out of State. Regions are defined as inside or outside the relevant NRDS, and then inside or outside the over-appropriated management areas. Western Canal Service area as defined in the documented model was delineated out of the SPNRD OA area. For the purpose of the total impacts for each NRD and the rest-of-model area, the following zones were combined as: NPNRD = zones 3 and 4 and SPNRD = zones 5 and 6. The management areas zone file was developed by assigning attributes to model grid cells using ArcGIS spatial join by centroid to NRDs and the Platte Basin Over Appropriated Area. NRDs and the Over Appropriated Area are explicitly defined as the regions encapsulated in the spatial join.

VI. Results

The acres changes, pumping and recharge differences, and resulting differences in stream leakage are summarized in two spreadsheets – one for each NRD/area. These spreadsheets are available at https://UPJointPlanning.nebraska.gov.

VII. Additional/Further Investigations

The results of this analysis are subject to the limitations of the modeling processes outlined in this documentation. Further investigations may be necessary to test the assumptions of this analysis and to assess the impacts of other management actions. Below is a short list of further investigations that we recommend:

- The sensitivity of annual depletions resulting from different climate representations

- The sensitivity of depletions to different crop type conversions on groundwater-only irrigated acres historically and when converting between groundwater only to dryland
- The sensitivity of annual and accounting point depletions to runoff and diversions and returns
- Updating conservation practices/more accurate representation of current farming practices

A.1.1 Robust Review Project Analysis Scope of Work

Exhibit A

Memo

To: POAC Technical Committee

From: Thad Kuntz (ARI) and Duane Woodward (CPNRD)

Date: 8/2/2016

Re: FINAL – Robust Review Project Analysis Scope of Work

Introduction

The Platte Overappropriated Area Committee (POAC) Technical Committee tasked Thad Kuntz from Adaptive Resources Inc. (ARI) and Duane Woodward from CPNRD to develop a scope of work for the Robust Review Analysis. The Districts included in this analysis are NPNRD, SPNRD, TPNRD, CPNRD, and TBNRD.

Robust Review General Scope of Work Description

A "change modeling" technique will be utilized for this analysis; this technique compares a baseline or reference model run (either the Western Water Use Management (WWUM) Model or Cooperative Hydrology Study (COHYST) Model) to a modified model run. The modified run introduces a change to a specific dataset in the baseline run and, when compared to the baseline, the difference is reflected in the stream baseflow, heads, or aquifer storage. The results from this technique do not represent actual estimates of future stream baseflow, streamflow, heads, or aquifer storage, but rather provide the estimated change in the stream baseflow, streamflow, heads, or aquifer storage.

Two phases of modeling will be completed to provide information for each District on post-1997 irrigated acreage development impacts, mitigation measures completed to offset those impacts, and effects of other water management actions each District has completed. Phase 1 modeling will encompass mitigation measures and management actions completed through 2013 while Phase 2 modeling will address additional analysis on surface water only and commingled acres, projects after 2013, and future water management planning for each District.

Phase 1 Modeling

The Phase I Robust Review modeling encompasses the post-1997 irrigated acreage development depletions and the management actions to mitigate these depletions. These actions include: excess flow canal recharge, ground water pumping allocations, certified acreage retirements, certified acreage transfers, surface water recharge projects, crop type changes, and municipal/industrial baseline changes. To complete Phase 1 Modeling, the POAC Technical Committee has identified the following baseline simulation and 7 individual analyses:

Baseline Run:

1. Existing Models
    a. WWUM Modeling
        i. Utilize the 1953 through 2014 Model
        ii. Only use 1997 through 2013 for the analysis
        iii. Modification to the Baseline Simulation
            1. Temporary retirements and transfers of certified ground water only irrigated acres occur in several NRDs and as a consequence the baseline simulation will need to be modified to

Memo

incorporate the reactivation or movement of these acres. To account for this affect, the baseline model will add these acres or move them to the original location, represented as irrigated corn, in the simulation when their temporary location expires.

iv. Repeat 2009 through 2013 climate into the future through 2063

v. Repeat the 2009 through 2013 pumping and recharge into the future through 2063

b. COHYST Modeling
   i. Utilize the 1950 through 2013 Model
   ii. Only use 1997 through 2013 for the analysis
   iii. Repeat 1988 through 2013 climate through 2063
      1. Hold the 2013 land use dataset (this is the 2010 land use dataset repeated through 2013) constant for the projection

c. Municipal, Industrial, and Livestock Pumping
   i. To complete the municipal, industrial, and livestock transfer and baseline analyses, both modeling efforts may need to revise the current estimates and locations of pumping and if not already in place, revise with actual pumping estimates for each category.

d. Canal Recharge Projects from Excess Flow
   i. The baseline models will need modified to incorporate the excess flow diversions for recharge.
   ii. To determine the amount of recharge from the diversion of excess flows a similar calculation to the NDNR Technical Memorandum for the 2011 Ground Water Recharge Demonstration Projects will need completed.

For all modified modeling analyses described below, each District will need to have separate analyses to determine their individual effects and compared to the baseline run described above. For the WWUM Modeling, each analysis using the regionalized soil water balance modeling will have only one run for both NPNRD and SPNRD. Post processing will split the run for each District.

Land Use Analysis:

1. *Increase in Post-1997 Irrigated Ground Water Only Acres*
   a. WWUM Modeling
      i. A set of model runs have been completed by ARI and the only additional work is two ground water model runs to separate out the effects of each NRD. No additional regionalized soil water balance modeling work will need to be completed. ARI will coordinate with NDNR, allowing NDNR to conduct the same analysis of increases in post-1997 irrigated groundwater only acres. NDNR will use the same input files and the same model version used by ARI to replicate the analysis, and the results of the two will be compared and evaluated to determine if the methods used meet the goals and objectives of the IMPs. This activity will take place as part of the Robust Review process.

b. COHYST Modeling
    i. To complete the analysis for CPNRD, TPNRD, and TBNRD individually, within each District the irrigation portion of the irrigated acres developed after 1997 will be removed from the land use dataset and ran through the watershed and ground water models to provide a streamflow value.

2. *Certified Irrigated Acreage Retirements (PBHEP, AWEP, CREP, EQUIP, NRD, etc.)*
    a. The retirement analyses will be completed separate from the Post-1997 depletions analysis. However, the effects from the retirements can be incorporated into the depletions analysis to provide the overall combined results.
    b. WWUM Modeling Area
        i. The retirement analysis will pump water at the retired parcel in the modified model each year using the projected pumping described in the baseline run.
            1. There is the possibility of double accounting for retirement effects if the lands were post-1997 developed lands. To mitigate this issue, the lands that were retired and developed after 1997 will not be analyzed in the retirement analysis. (SPNRD has no post-1997 retired acres, NPNRD estimates that 130 retired acres were post-1997 lands.)
    c. COHYST Modeling Area
        i. The retirement analysis will pump water at the retired parcel in the modified model each year as if the parcel grew corn from the retirement date to the end of the analysis.
            1. There is the possibility of double accounting for retirement effects if the lands were post-1997 developed lands. To mitigate this issue, the lands that were retired and developed after 1997 will not be analyzed in the retirement analysis.
3. *Certified Irrigated Acreage Transfers*
    a. The transfer analyses will also be completed separate from the Post-1997 depletions analysis. However, the effects from the transfers can be incorporated into the depletions analysis to provide the overall concept of combining the results.
    b. WWUM and COHYST Modeling Areas
        i. In the modified model:
            1. Water will be pumped at the pre-transferred location using the crop type and pumping amount of the post-transferred location. New irrigation recharge will be estimated will be provided for each pre-transferred location. The future projection will be completed as described in the baseline run.
            2. The post-transferred location will be converted to dryland pasture in the WWUM Modeling and dryland crop in the COHYST Modeling.
            3. If the transfer is to an industrial use, then the efficiency of that new use must be estimated for the simulation.
4. *Variances Granted Since July 1, 1997*

a. Each variance will need individually conceptualized and an analysis will need to be completed.
b. NDNR has compiled a list of the variances provided by the NRDs that have occurred over this timeframe. It is anticipated that each individual variance can be categorized into one of the previous categories: Increase in acres, retirements, or transfers.

Change in Crop Mix Analysis:

1. *Changes in Crop Consumptive Use from Changes in Crop Mix as Compared to 1997 Crop Mix*
   a. This phase of the project will investigate the changes in crop consumptive use since 1997. This will be completed by determining the annual total consumptive use and comparing it to the 1997 annual consumptive use.

Canal Recharge Projects Analysis:

1. *2011 Ground Water Recharge Demonstration Project*
   a. In the modified model, this will be completed by removing the amount of excess flow diversions and associated recharge.
2. *2013 South Platte River Flood Flow Diversion and Recharge*
   a. In the modified model, this analysis can be completed by removing the recharge from the diversion of excess flows.
3. Phelps County Canal Recharge Project
   a. In the modified model, this analysis can be completed by removing the recharge from the diversion of excess flows into Phelps canal during the winter months.
4. Elwood Reservoir Ground Water Recharge Project
   a. In the modified model, this analysis can be completed by removing the recharge from the diversion of excess flows into Elwood Reservoir.

Augmentation Project Analysis:

1. *North Dry Creek Augmentation Project*
   a. In the modified model, this analysis can be completed by removing the pumping into dry creek during the time period water was pumped.

Allocation Analysis (NPNRD and SPNRD Only):

1. *Ground Water Allocations (North Platte and South Platte NRDs Only)*
   a. A set of model runs have been completed by ARI and the only additional work is two ground water model runs to separate out the effects of each NRD. No additional regionalized soil water balance modeling work will need to be completed. ARI will coordinate with NDNR, allowing NDNR to conduct the same analysis evaluating the allocations. NDNR will use the same input files and the same model version used by ARI to replicate the analysis, and the results of the two will be compared and evaluated to determine if the methods used meet the goals and objectives of the IMPs. This activity will take place as part of the Robust Review process.

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Municipal, Industrial, and Confined Livestock Feeding Operation Baseline and Transfer Analysis:

1. *Changes in Municipal, Industrial, and Confined Livestock Feeding Operations Consumptive Use and Location of Pumping as Compared to Their Baseline*
   a. In the modified model:
      i. For municipal baseline pumping from 1998 through 2013, the calculated baseline annual per capita consumptive use will be multiplied by the annual population of 1997 and will be compared to the baseline run's actual pumping amount.
      ii. For industrial baselines from 1998 through 2013, the 1997 estimates of pumping for each industry will be fixed to compare against the actual pumping in the baseline run.
      iii. For livestock baselines from 1998 through 2013, the average gallons/head/day will be multiplied against the 1997 cattle of feed for each NRD tracked livestock facility and compared to the baseline run's actual pumping.
   b. To determine the effect of municipal, industrial, or livestock transfers, in the modified model, the pre-transferred pumping locations will be used. The post-transferred pumping locations will be removed from the modified model.

Overall Robust Review Analysis:

1. Overall analysis will combine each analysis into a single run.
   a. The overall analysis will encompass the following changes:
      i. Land Use Analysis
      ii. Canal Recharge Projects Analysis
      iii. Augmentation Projects Analysis
      iv. Allocation Analysis (NPNRD and SPNRD Only)
      v. Municipal Baseline and Transfer Analysis
   b. **Some of these changes may not be able to be analyzed together so a composite of the combined and individual analyses may need to be utilized in order to complete this analysis.**

Documentation for All Analyses

The change results will be determined and presented for each of the individual analysis listed above (e.g. Land Use Analysis, Change in Crop Mix Analysis, etc.) and by District. Additionally, complete overall documentation for the process, assumptions, and results will be presented in a single document for the Platte Basin area.

Project Timeline

The Phase 1 modeling analyses need completed by December 31st, 2016. In early 2017, the information and draft documentation will be provided to the POAC Technical Committee and Administrators for review and discussion.

Memo

Phase 2 Modeling

The Phase II modeling will be completed to provide each District with information on the post-1997 irrigated acre development impacts, projects, and management actions that are in the in development after 2013 that will effect stream baseflow or streamflow through the first increment and into the future. The future projects and management actions include canal recharge, allocations, certified acreage retirements, certified acreage transfers, surface water recharge projects, idled certified acres, crop type changes, and municipal/industrial baseline changes. Additionally, different climatic conditions may exist in the future that may include wet and dry scenarios and modeling can be completed to help inform each District's water resource management planning. Additionally, commingled pumping will be addressed in Phase 2 Modeling. The Phase 1 Modeling will be used as the modeling or a template of the modeling needed for this phase of the Robust Review Analysis.

Below is a list of potential projects being considered for Phase II modeling:

- Temporary Surface Water Only and Commingled Land Retirements
- Climatic Conditions
- Change in Crop Mix (If Needed)
- Commingled Acres
- Canal Rehabilitation: Cozad, Orchard-Alfalfa, Thirty-Mile
- Nebraska Cooperative Republican Platte Enhancement Project
- J-2 Regulating Reservoir
- Elm Creek Reservoir Potential Excess Flow Storage
- Surface Water Transfer Recharge/Stream Augmentation Projects (NPNRD)
- Future High Flow Canal Recharge Projects (Similar to the 2011 and 2013/2014 Recharge Projects)
- Planned Projects (after 2013)
- Conversion from Surface Water Only Irrigation to Commingled Irrigation
- Conversion from Surface Water Only Irrigation to Ground Water Only Irrigation (CPNRD)

A.1.2 Memorandum on the COHYST2010 Watershed Model Update – Run029

COHYST2010 MODELING TOOL UPDATE
WATERSHED MODEL RUN029

TECHNICAL MEMORANDUM

TO: Nebraska DNR Technical Staff
FROM: Marc Groff
Isaac Mortensen
RE: COHYST2010 Watershed Model Update – Run029
DATE: 15 June 2018

Introduction

The COHYST modeling tool was initially developed in 1998 as part of the Cooperative Hydrology Study (COHYST) which is a hydrologic study focused on the Platte River drainage basin in Nebraska. The modeling tool has undergone several revisions since that time. The original 1998 model was comprised of three ground water models covering the area from the Wyoming border to approximately Duncan, NE. That tool evolved into the Western Water Use Model (WWUM), which covers the Nebraska Panhandle area, and COHYST2010, which covers the area from the Panhandle to Duncan, NE. Both the WWUM and COHYST2010 tools are integrated models comprised of a ground water model, a surface water operations model, and a watershed response model. Run028 was the version of the watershed response model described in the current COHYST2010 documentation (refer to http://cohyst.nebraska.gov/ for a copy of that documentation).

The purpose of this memorandum is to document a couple of updates being made to Run028 of the watershed response model in the COHYST2010 tool. The incorporation of these changes will result in a new watershed model version, Run029, which will be used within the COHYST2010 tool supporting the Robust Review modeling project.

Watershed Model Updates

As discussed in Section 5 of the COHYST2010 modeling report, the watershed model has four components: a climate model; a point source soil water balance model; spatial and temporal distribution routines; and a regionalized soil water balance model. The Run029 updates affect two of these components: the climate model; and the point source soil water balance model.

With respect to the climate model, the update reflects a change necessitated by changes in data availability. Specifically, two climate stations (Tryon and Arnold) are no longer supported. Therefore, the station located near Stapleton, NE (Stapleton_5W) was incorporated into the input dataset in their place. Figure 1 below (which is Figure 5.4 in Section 5 of the COHYST2010 modeling report) shows the locations of these stations.

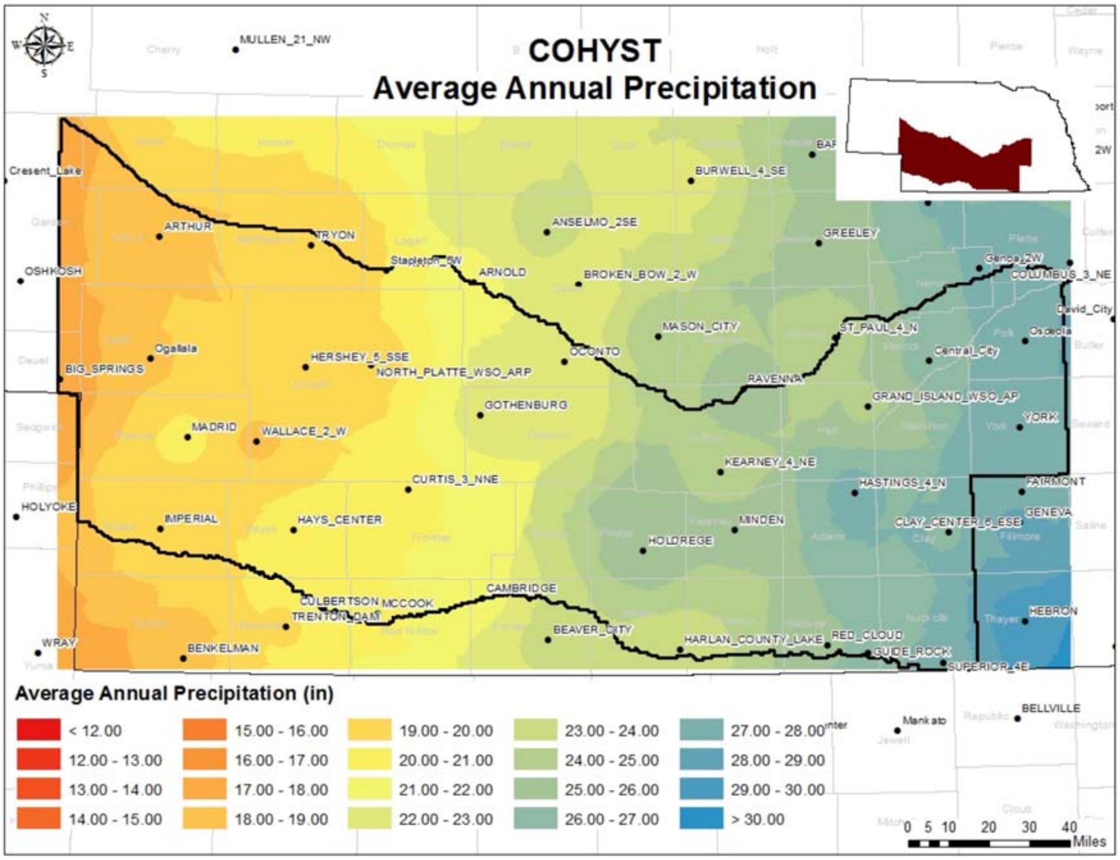

Figure 1: Climate Station Locations

With respect to the point source soil water balance model, the soil water balance model CropSim is used within the watershed response model. Run028 used CropSim version 7.9 and Run029 uses CropSim version 8.0. The version 8.0 update to CropSim addressed two coding issues: ensuring that a variable used to track the partitioning of soil water within CropSim's 10 layer soil model properly resets; and normalizing the numeric format of data being read and written to the data file which stores the initial water content in the soil profile prior to a simulation being run. The first coding update corrects an issue which occurred under wet conditions on irrigated lands that resulted in potentially more recharge being allowed out of the root zone than should have been. The general effect of implementing the update was a small reduction in recharge under the identified condition. The second issue updated coding statements such that data would be both read and written to three decimals of precision. Previously, data was being written to two decimals of precision.

Impacts to Modeling Results

In general, updating the watershed response model with COHYST2010 to Run029 has a minimal impact on the overall results from the watershed model. Table 1 below shows the change in long term average water balance values for select terms of interest. Table 1 is based on Table 5.4 in the current COHYST2010 documentation.

Table 1: Comparison of long term average water balance terms

Parameter	Run028	Run029	Change in Average
Precipitation	24,112,174	24,133,809	21,635
Surface Water Deliveries	221,170	221,341	171
Groundwater Pumping	2,448,889	2,461,605	12,716
Total Applied Water	26,782,233	26,816,756	34,522
Field Evapotranspiration	21,994,798	22,292,473	297,675
Field Recharge	2,647,784	2,507,367	(140,418)
Field Runoff	2,011,730	1,965,506	(46,223)
Surface Losses	129,080	129,721	641
Lateral Losses	15,038	15,039	1
Field Water Balance	(1,158)	(78,311)	(77,153)
Field Runoff Balance	2,011,730	1,965,506	(46,223)
Runoff Losses to Recharge	436,584	426,936	(9,648)
Runoff Contributions to Streamflow	1,138,562	1,111,635	(26,927)
Runoff Losses to Evapotranspiration	436,584	426,936	(9,648)
*Units are in Acre-Feet (AF)			

There are localized areas within the model domain which do reflect a greater response to the updates. A presentation developed by the technical staff at the Nebraska Department of Natural Resources (DNR) highlights the changes in these areas through an evaluation of relative water level changes and predicted streamflow changes output from COHYST 2010 when using Run029 versus Run028 of the watershed model . Even in these locations, it is TFG's belief that the magnitude of change does not rise to the level of warranting any type of COHYST2010 recalibration.

Summary

The COHYST2010 toolset is comprised of several individual models and their associated datasets. This modular construction is a major advantage to keep COHYST2010 current with changing inputs and updated modeling tools. The updates discussed in the memorandum reflect proper model and input dataset maintenance. Incorporating these changes now will ensure that the Robust Review project is evaluated with the most current and up to date toolset available.

A.1.3 Memorandum on COHYST2010 area Model Runs

Memorandum

To: Kari Burgert, DNR

From: The Flatwater Group, Inc.

Subject: Robust Review – COHYST area Model Runs

Date: 11/26/2018

INTRODUCTION

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (MPs). The focus of this memorandum is to identify the scenario simulations created for the Robust Review project and define their setup.

The remaining discussion within this document is organized into four sections:

Section 0 of this memorandum describes the setup of the model TFG used to develop these files.

Section 0 describes the first iteration of the of the Robust Review scenarios and the inputs used to create the simulations. TFG's task originally consisted of developing three simulation runs, with multiple Municipal and Industrial (M&I) pumping scenarios. However, the groundwater land use modifications to the baseline and the unretired scenario were limited to Tri-Basin NRD and Twin Platte NRD.

- 0. Baseline Scenario
- 0. Unretired Scenario
- 0. Post 1997 Development Rollback Scenario
  - 0. 1997 level of M&I development
  - 0. Historical level of M&I development

Section D describes requested updates to land use and M&I pumping information made by the three Natural Resource Districts (NRDs) in the COHYST model domain area during the course of the Robust Review project.

Section E describes the updated Robust Review scenario simulations created to implement the changes described in Section D. It contains a list of the Robust Review simulations with a description of how each scenario was represented. Section E is organized as follows:

- 0. Baseline Scenario
  - 0. No M&I pumping
- 0. Unretired Scenario

0. Post 1997 Development Rollback Scenarios
    0. 1997 level of M&I development
    0. Historical level of M&I development
    0. No M&I pumping
0. No Groundwater Only Pumping Scenario

Section 0 described the updates to the Unretired Scenario land use data set to fix the acres unretired to account for post 2010 temporary retirements being implemented at twice the area of these retirements. This accounted for 40.8 acres in TPNRD and 111.3 acres in TBNRD.

Section 0 describes the updated Robust Review Unretired Scenario simulation created to implement the changes described in Section 0. It contains a list of the simulation with a description of who the scenario was represented. Section 0 is organized as follows:

A1. Unretired Scenario

MODEL SETUP

The watershed model utilized for the Robust Review was based upon the calibrated Cooperative Hydrology Study (COHYST) 2010 watershed model. Additional inputs were incorporated from the Conservation Study's Baseline (Base001). Several modifications were necessary to implement the scenarios through the watershed model.

A1. MODEL STRUCTURE

The Robust Review model runs include a historical period (1950-2013) and a projected period (2014-2063). The Watershed model was modified to draw Water Balance Parameter (WBP) data from two sets. The first set uses the traditional time trended WBPs that represent the change in farming practices over time. This set is applied to the historical period. The second set switches to the WBP developed using the most current set of farming practices. This set is applied to the projected period.

CLIMATE

The WBP input data sets implemented in the COHYST 2010 model were updated for the Robust Review in the COHYST model area. Two changes were made to the CROPSIM model (v8.0). The first change updated the recharge routine from precipitation on irrigated simulations during the irrigation season. A second change made the transfer of soil water content between subsequent years consistent on the number of decimals passed between variables.

The same COHYST weather stations were simulated for the circa 1950s, 1970s, and 2000s farming practices and then time trended over the historical period. The time trended information was spatially gridded to create the COHYST WBP data set Run002\Grid_TT for application in Robust Review's historical period. The Circa 2000s information was spatially gridded to create the COHYST WBP data set Run002\Grid98 for application in the Robust Review's projected period.

LAND USE

Multiple land use data sets were implemented in the Robust Review within the COHYST area to hand the different modeled scenarios.

BASELINE LAND USE (RR001\LU004_RR2013EXT)

The first step was to establish a baseline land use. The Robust Review Land Use used land use data sets for the period 1950 to 2013. The 1985-2010 land use was consistent with the land use used in COHYST 2010. The 1950-1984 land use was obtained from the 2013 FAB analysis. This was also consistent with the way land use was represented in the Conservation Study. The period 2011-2013 was created by adding and removing the NRD and DNR specified retirements, transfers, and variances from the 2010 land use file. The land use modifications were applied to groundwater only irrigated lands. Surface water only and comingled lands were not altered. With the exception of the 6 Mile canal which was converted completely to comingled and the GWC was set to 1.0 effectively making these lands groundwater only irrigated. The 2014-2023 period was further modified to accommodate temporary retirement contracts ending[1]. At the time of the first Robust Review Iteration the land use modifications were applied for Twin Platte NRD and Tri-Basin NRD.

Details about the modifications made to the Land use data sets can be found in the Land Use Memorandums[2]:

TBNRD_RR_Memo_20180713.docx
TPNRD_RobustReview_LU_20180713.docx

Unretired Scenario Land Use (RR001\LU004_rr2013mod)

The second set was to develop to capture the influence of the retired groundwater only irrigated acres. The baseline land use was modified to add back in the temporary and permanently retired groundwater only irrigated acres. No modifications were made to surface water only or comingled lands. At the time of the first Robust Review Iteration the land use modifications were applied for Twin Platte NRD and Tri-Basin NRD.

Details about the modifications made to the Land use data sets can be found in the Land Use Memorandums[3]:

TBNRD_RR_Memo_20180713.docx
TPNRD_RobustReview_LU_20180713.docx

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[1] A ten-year temporary retirement would only be retire for 10 years as opposed to persisting throughout the projected period.

[2] The land use memos were updated to account for changes requested by the NRDs and the implementation of the CPNRD modifications.

[3] The land use memos were updated to account for changes requested by the NRDs and the implementation of the CPNRD modifications.

Post 1997 Groundwater Development Rollback Land Use (LU004p97)[4]

The post 97 data set was developed by making alterations to the baseline data set. For the years 1953 through 1997 the land use remained constant. Between the 1998 and 2013 surface water only and comingled lands were developed as seen in the Baseline Data Set, while groundwater only irrigated lands were kept at 1997 levels. The balance of the acres within a cell were handled one of three ways

- If the number of irrigated acres in the cell exceeded 160.0 acres[5], the excess acres irrigated acres remained in the model and the dryland acres were set to 0.0. The annual total of the excess acres never exceeded 10,000 acres. Averaging 2,100 acres from 1998-2005 and 9,200 acres from 2006-2013. The overwhelming majority of this acre imbalance occurred in the Republican River, Big Blue River, and Little Blue River Basins.
- IF the irrigated acres were less than 40.0 acres, but the irrigated acres plus the dry acres were greater than 160.0 acres; acres were removed from the dryland crops until the total number of acres was equal to 160.0.
- If the irrigated acres plus the dryland acres was less than 40.0 acres, the balance was added as dryland corn.

Irrigation Estimates

All groundwater only irrigation estimates were simulated to meet a target NIR.

The Robust Review used the Surface Water Irrigation District surface water deliveries from the Conservation Study[6]. This deliveries data set spanned from 1950 through 2013. For the projected period (2014-2063) the total canal deliveries were copied to match the climate year. This total was then divided among the acres to receive surface water as specified by the simulation year land use file[7]. For surface water only and comingled lands not in the surface water operations model, the irrigation volumes were simulated to meet a target NIR.

Comingled pumping was implemented in the same manner as the COHYST 2010 model. A portion of the target NIR designated by the Groundwater Concentration Factor (GWC) is meet by pumping. Additionally, if the surface water deliveries were insufficient to meet the demanded deliveries (1-GWC), pumping was applied to make up the deficit.

The same surface water deliveries and comingled pumping were applied to each scenario.

Canal Recharge

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[4]All of the NRD and DNR specified modifications to the groundwater irrigated acres happened in1999 or later. This means that the post 1997 groundwater development rollback land use data set was not altered by these changes.

[5]Irrigated acres are defined as the total of the land use file year's surface water only and comingled irrigated acres plus the 1997 groundwater only irrigated acres.

[6]The Robust Review was not running the COHYST Surface Water Operations Model.

[7] Example: In 2014 Cozad Canal would receive the 1989 volume of deliveries which would be divided over the 2014 surface water only and comingled lands serviced by the Cozad Canal.

The Robust Review used the Republican River canal recharge from the COHYST 2010 model. The 1950-1984 canal recharge was copied from 1985. The 2011-2013 canal recharge was copied from 2010 which was in turn originally copied from 2005. (RRcnl001)

Municipal and Industrial (M&I) Pumping

The Robust Review used the M&I pumping from the Statewide M&I data set in the COHYST model area (MI001).

Robust Review Scenarios (Iteration 1)

Using the setup and updates described in Section 0, the watershed model was used to simulate a variety of scenarios for the Robust Review and create the corresponding inputs for the groundwater model. Section 0 contains a list of these simulations with a description of how the scenario was represented.

A1. Baseline Scenario (Base001)

Deliverable: RobustReview_Base001_20180711.zip

Date: 7/11/2018

Simulated Period (1950-2013)

Climate:	1950 – 2013
Land Use:	Baseline Extension (RR001\LU004_rr2013ext)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes
M&I Pumping:	Yes

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Baseline Extension (RR001\LU004_rr2013ext)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge:	Yes – match simulated year
M&I Pumping:	Yes – Uses the 2013 estimate

Unretired Scenario (MOD001)

Deliverable: RobustReview_MOD001_20180711.zip

Date: 7/11/2018

Simulated Period (1950-2013)

Climate:	1950 – 2013
Land Use:	Unretire Acres (RR001\LU004_rr2013mod)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes
M&I Pumping:	Yes

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Unretire Acres (RR001\LU004_rr2013mod)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	Yes – Uses the 2013 estimate

Post 1997 Groundwater Development Rollback Scenario (dP97_001)

Post 197 Groundwater Development Rollback Scenario 1997 Level of M&I

Deliverable: RobustReview_dP97_001_20180720.zip

Date: 7/20/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MI001)

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes – At 1997 levels of pumping (MI001)

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Post 97 GW Scenario 2013 Land Use (LU004p97)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	Yes – At 1997 levels of pumping (MI001)

Post 197 Groundwater Development Rollback Scenario with Historic Levels of M&I

Deliverable: RobustReview_dP97_001_20180716.zip

Date: 7/16/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MI001)

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MI001)

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Post 97 GW Scenario 2013 Land Use (LU004p97)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	Yes – At 2014 estimate levels of pumping (MI001)

*The output of this run is no longer on the TFG server. Only the results provided to DNR remain. The output was replaced with 1997 level of M&I pumping before it was determined that both sets of information were desired. This run could be replicated, but the subsequent Post 1997 runs would replace this run in the Robust Review Analysis.

Robust Review COHYST Area Updates

A second iteration of the Robust Review was completed to accommodate the changes to groundwater only irrigated acres in the Central Platte NRD. Furthermore, the requested changes from TPNRD and TBNRD were also implemented. The following changes were made:

A1. Land Use

The Baseline Land Use data set and the Unretired Scenario Land use data sets were updated as follows:

- The CPNRD retirements, transfers, and variances were implemented into both data sets
- The TBNRD temporary retirement '*Pheasants Forever*' contract term was changed from 4 years to 5 years

This information was combined with the previous modifications to create new data sets:

Baseline Land Use (RR002\LU004_rr2013ext_002)
Unretired Scenario Land Use (RR002\LU004_rr2013mod_002)

Details about the modifications made to the baseline and unretired scenario land use data sets can be found in the Land Use Memorandums[8]:

CPNRD_RR_LUmemo_LU20181017.pdf
TBNRD_RR_Memo_LU20181017.pdf
TPNRD_RobustReview_LU20181017.pdf

No Groundwater Pumping Scenario Land Use (RR002\LU004_rr2013ext_002_ngwp)

The No Groundwater Pumping Scenario land use converted all groundwater only irrigated acres in the Baseline Land Use Data Set (RR002\LU_rr2013ext_002) to dryland acres of the same crop mix. Surface water only and comingled land use remained unchanged.

Municipal and Industrial (M&I) Pumping

The industrial pumping from the Gerald Gentleman Power Station (GGS) in the TPNRD was modified to use estimates developed by Nebraska Public Power District (NPPD) in their annual reports. The COHYST M&I data set (MI001) was modified by moving the GGS pumping data to their own set of inputs:

Details about the modifications made to the M&I data sets can be found in the M&I Memorandum:

GGS_update_20181022.docx

[8] The land use memos were updated to account for changes requested by the NRDs and the implementation of the CPNRD modifications.

COHYST M&I for the Robust Review (MIrr001)

Contains the information from the COHYST M&I data set (MI001) sans the GGS pumping estimates.

Gerald Gentleman Station Pumping (GGSrr_002)

Contains the new pumping estimates for GGS.

Robust Review Scenarios (Iteration 2)

The newly updated inputs developed in Section 0 were implemented into the watershed model to create a new set of Robust Review scenario simulations and the corresponding inputs for the groundwater model. Section 0 contains a list of these simulations with a description of how the scenario was represented.

A1. Baseline Scenario (Base002)

Deliverable: RobustReview_COHYST_Base002_20180831.zip
Date: 8/31/2018

Simulated Period (1950-2013)

Climate: 1950 – 2013

Land Use: Baseline Extension (RR002\LU004_rr2013ext_002)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Baseline Extension (RR002\LU004_rr2013ext_002)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: Yes – Uses the 2014 estimate

Baseline Scenario – No Municipal and Industrial Pumping (Base002_SansMI)

Deliverable: RobustReview_COHYST_Base002_sansMI_20180905.zip

Date: 9/5/2018

Simulated Period (1950-2013)

Climate:	1950 – 2013
Land Use:	Baseline Extension (RR002\LU004_rr2013ext_002)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes
M&I Pumping:	No

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Baseline Extension (RR002\LU004_rr2013ext_002)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	No

Unretired Scenario (Mod002)

Deliverable: RobustReveiw_COHSYT_MOD002_20180831.zip

Date: 8/31/2018

Simulated Period (1950-2013)

Climate: 1950 – 2013

Land Use: Unretired Acres (RR002\LU004_rr2013mod_002)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Unretired Acres (RR002\LU004_rr2013mod_002)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: Yes – Uses the 2014 estimate

POST 1997 GROUNDWATER DEVELOPMENT ROLLBACK SCENARIO (DP97_001)

These runs use the same agricultural pumping and recharge from the *Post 1997 Groundwater Development Rollback Scenario (dP97_001)* from Section 0. The difference between the runs is the municipal and industrial pumping data sets which were applied and the way they were applied.

POST 1997 GROUNDWATER DEVELOPMENT ROLLBACK SCENARIO WITH 1997 LEVEL OF M&I

*Updated with new M&I data sets

Deliverable: RobustReview_dP97_001_MIrr001_20180904.zip

Date: 9/4/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MIrr_001, GGSrr_002)

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes – At 1997 levels of pumping (MIrr_001, GGSrr_002)

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Post 97 GW Scenario 2013 Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: Yes – At 1997 levels of pumping (MIrr_001, GGSrr_002)

Post 1997 Groundwater Development Rollback Scenario with Historical Levels of M&I

*Updated with new M&I data sets

Deliverable: RobustReview_dP97_001_MIrr001HistDev_20180905.zip

Date: 9/5/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MIrr_001, GGSrr_002)

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MIrr_001, GGSrr_002)

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Post 97 GW Scenario 2013 Land Use (LU004p97)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	Yes – At 2014 estimate levels of pumping (MIrr_001, GGSrr_002)

Post 1997 Groundwater Development Rollback Scenario with No M&I

Deliverable: RobustReview_dP97_001_MIrr001_none_20180904.zip

Date: 9/4/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: No

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: No

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Post 97 GW Scenario 2013 Land Use (LU004p97)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	No

No Groundwater Only Pumping Scenario (nGWP_003)

Deliverable: RobustReview_nGWP_003_20180906.zip

Date: 9/6/2018

Simulated Period (1950-2013)

Climate: 1950 – 2013

Land Use: Baseline Extension No Groundwater Only Lands (Lu004_rr2013ext_002_ngwp)

Groundwater Pumping: None

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: No

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Baseline Extension No Groundwater Only Lands (RR002\LU004_rr2013ext_002_ngwp)

Groundwater Pumping: None

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: No

Robust Review COHYST Area Updates (Iteration 2.1)

The second iteration of the Robust Review was modified after identifying a data discrepancy between the unretired acres scenario and the cumulative retirements. It was determined that the temporary retirements after 2010 were being added back in at double the rate they should have been. This resulted in 40.8 additional GW only acres in TPNRD and 111.3 additional GW only acres in the TBNRD. The land use data set for the Unretired Scenario was rebuilt to remove the additional unretire acres. No other changes were made.

A1. This created the land use data set:

Unretired Scenario Land Use (RR002\LU004_rr2013mod_002.1)

This land use dataset was created with the same method and inputs as 0; the only exception was that the post 2010 temporary retirements were not added back into the data set. This was not necessary as the modified data set was extended from the 2010 land use from COHYST 2010; as opposed to the modification being made to the extended baseline dataset. Details about the modified data sets can be found in the Land Use Memorandums[9]:

CPNRD_RR_LUmemo_LU20181121.pdf

TBNRD_RR_Memo_LU20181121.pdf

TPNRD_RobustReview_LU20181121.pdf

[9] The land use memos were updated to account for the removal of the double addition of unretired acres.

Robust Review Scenario (Iteration 2.1)

The newly updated inputs developed in Section 0 were implemented into the watershed model to create a new Unretired Scenario simulation and the corresponding inputs for the groundwater model. Section 0 summarizes the inputs used to represent the scenario within the model.

A1. Unretired Scenario (Mod002)

Deliverable: RobustReveiw_COHSYT_MOD002.1_20181121.zip
Date: 11/26/2018

Simulated Period (1950-2013)

Climate: 1950 – 2013

Land Use: Unretired Acres (RR002\LU004_rr2013mod_002.1)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Unretired Acres (RR002\LU004_rr2013mod_002.1)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: Yes – Uses the 2014 estimate

A.1.4 Memorandums on Municipal, Industrial, and Domestic Use for COHSYT2010

Appendix 4-R

Processing Municipal, Industrial, and Domestic Withdrawals and Discharge

Appendix 4-R.
COHYST M & I
Municipal, Industrial, and Domestic Withdrawals and Discharge
Data Acquisition, Estimation, and Incorporation into the COHYST Grid.

To: COHYST Group
From: The Flatwater Group
Subject: M & I write up
Date: 9/19/2011

This memo describes the production of municipal, domestic, and industrial datasets by The Flatwater Group, Inc., for use in the COHYST 2010 numerical ground water model from 1985 to 2010. Using available sources of withdrawals, returns, and population, "baseline" conditions were developed monthly for each entity in the region. Domestic consumptive use was determined from pumping withdrawals and returns converted to a per capita volume, and trended according to annual population estimates. The Industrial consumptive use baseline was developed using data acquired from the surveys mailed to industrial water users. When calculating consumptive use, large industrial uses were separated from municipal uses.

The databases were combined and applied to the COHYST grid in GIS with a descriptive rate of acre-feet per month. Data sources and method used to estimate municipal, industrial, and domestic withdrawals and returns within the eastern and central portions of the COHYST model region are described below.

DATA Sources

Data used in estimating the industrial and municipal withdrawals for the eastern and central portions of the COHYST area were acquired from several locations. The Department of Natural Resources (DNR), local natural resource districts (NRD) (Central Platte NRD, Tri-Basin NRD, Twin Platte NRD), and the United States Geological Survey (USGS) provided pumping measurements and estimates. DNR, NRDs, and the Nebraska Department of Environmental Quality (DEQ) provided discharge measurements and estimates. Information on population and demographics was acquired from the DNR and combined with data from the United States Census Bureau and USGS. The spatial location of the wells was attained from DNR.

DNR circulated two types of water use surveys to industries throughout the COHYST area. In addition, DNR provided population estimates for the COHYST counties and municipalities during several inter-census years. Finally, the DNR provided spatial information on the location of municipal, domestic and industrial wells across the area in the form of the registered groundwater wells database.

The first survey type was titled “Historical Surveys”. Many of the industries surveyed receive their water source from municipal water supplies. This was reported in the upper right-hand section of the first page of the survey. Requested information included industry type, method of discharge, location of discharge if into a stream, DEQ NPDES permits, and the technique used to acquire the annual or monthly data (metered or estimated).

A second DNR water use survey was sent to owners of registered industrial wells. The survey included a list of wells used at an industrial location and requested information on any other wells that were used to supply water to the industry. The survey requested information on the industry type, well, DEQ NPDES permits, and the location where waste water was discharged into the stream, along with monthly or annual pumping and discharge values or estimates and the technique used to arrive at these estimates.

The USGS prepares withdrawal estimates in the form of a USGS water use circular titled “Estimated use of Water in the United States”. These Water use estimates are published every 5 years. Electronic data on a county-level were available from 1985 to the most current publication in 2005. USGS’s water use circular includes withdrawal estimates from publicly supplied water sources, self-supplied domestic water use, self-supplied industrial water use, irrigation, livestock production, mining, thermoelectric power production, and withdrawal totals on a statewide basis, with background data available on a county-level. The water use circulars also include estimates of total population, self-supplied population and publicly supplied population.

For the USGS circulars, the source of all self-supplied domestic withdrawals in Nebraska is assumed to be groundwater. A county’s self-supplied population was calculated as the difference between the total county population and the estimated publicly-supplied population. Withdrawals were estimated based upon the self-supplied population and the average zonal[1] residential delivery per-capita rate based on the results from the public water system survey. Data sources for the self-supplied domestic withdrawals in the 2005 water use circular include the following: a public water supply

[1] As defined by the USGS estimation methods for the self-supplied domestic population withdrawals.

database maintained by the Nebraska Department of Health and Human Services System; a DNR 2005 Public Water System Survey; USGS Water Use in Nebraska, 2000 (USGS); DNR 1995 Water Use Report, and a U.S. Bureau of Census, 2006, 2000-2005 County Population Estimates report.

Besides information on withdrawals, estimates of returns were also obtained. Municipal and Industrial water users who discharge waste water into the streams are required to submit discharge monitoring reports (DMR) to the DEQ. These discharge reports were obtained, when available, to confirm the amount of wastewater discharged by the industry or municipality.

United States Census Bureau records were also used to acquire population estimates for the municipalities and counties that were in the eastern and central portions of the COHYST area. Population estimates from the census were available on a ten-year basis.

Industrial Data and Estimates

The data supplied by the industry contacts came in several different formats. Industries typically provided monthly or annual data based upon metered pumping data, while a few provided summaries of utilities statements. However, many of the industries did not have meters on either their water source or discharge point, and several cited this as the reason they were unable to report their water use. Other industries attempted to make good-faith estimates of either monthly or annual values based on their instantaneous pumping rates, consumption rates, or other methods.

Industries that possessed a DEQ NPDES permit often did not include discharge data, and instead referred to the DMRs submitted to the DEQ. Discharge data were acquired for sites with NPDES permits to match the time period for which the industry supplied withdrawal records.

The metered and estimated data, as well as the DEQ DMR discharge values, were compiled into a database for each surveyed location. While the scope of the project was to investigate municipal and industrial water use from 1985-2010, none of the industrial records were complete for the entire time period. To account for these limitations, estimation techniques were developed to fill in the gaps.

Partially completed set of monthly data points for a year

This first technique was used for those situations where there were unknown monthly water withdrawal values in partially reported years. Water use was not consistent throughout the year for many industries; there were periods where withdrawals were relatively higher or relatively lower. This may be due to a variety of reasons, but when estimating unknown values, it was important that an attempt be made to account for these temporal patterns.

Using years where a complete set of monthly data was available, the monthly distribution for each year was developed by calculating the average proportion of the annual withdrawals that occurred during each month. Using this average monthly distribution, the total amount of withdrawals were estimated by averaging the quantity of the known monthly value divided by the average monthly withdrawal proportion for those months where withdrawal data were available.

$$\widetilde{W_a} = \frac{\sum_{i=1}^{n} \frac{W_i}{\overline{P_i}}}{n}$$

$\widetilde{W_a}$ Estimated annual withdrawals

W_i Known monthly withdrawal for month i

$\overline{P_i}$ Average monthly proportion of the annual distribution of withdrawals $\left(\sum_{i=1}^{12} \overline{P}_i = 1.0\right)$

n Number of months with available monthly withdrawal data

The unknown monthly values were estimated by multiplying the estimated annual withdrawals by the corresponding average monthly proportion of the annual distribution of withdrawals. This same technique was applied to the discharge values to estimate missing monthly data points in an incomplete year.

Missing annual and monthly data

For some industrial withdrawal records, entire years' worth of records were missing. For these situations, annual withdrawal data were estimated, using an established procedure. The industries were investigated to ensure that they were operational during the investigation period, and that if they had private wells, that those wells were present during a given year. If the industry had multiple wells, and one or more of those wells was completed during the investigation time period, the estimated withdrawals by the industry were prorated according to the pumping capacity of active wells compared to total pumping capacity for the years prior to the completion date of the well or wells in question. If the industry used a consistent amount of water each year, it was assumed that the pattern for the known period persisted during periods with missing records, and this annual amount was then applied to all the missing years.

Withdrawals for industries that saw fluctuating annual amounts were estimated by considering the average portion of non-irrigation pumping within a respective county that could be attributed to the particular industry. Using the supporting data from the USGS circulars for the years 1985-2005, estimates for the total irrigation withdrawals and the total county withdrawals were obtained. Irrigation encompasses the majority of the total withdrawals for most of the counties of interest. By removing the irrigation estimate from the total estimate, an estimate of the non-irrigation withdrawals was developed. The non-irrigation annual withdrawals for the year 2010 were estimated as either the average of 1985-2005 withdrawals if the volume of water being withdrawn was fluctuating up and down over time, or using a linear regression trend if there was a persistent growth or decline over the time period. Linear interpolation was used to determine the intermediate values.

$$W_t = W_a + (W_z - W_a)\left(\frac{Y_t - Y_a}{Y_z - Y_a}\right)$$

W_t	Estimated non-irrigated withdrawals for a year between Y_z and Y_a
W_a	Estimated non-irrigated withdrawals for a known year prior to the year of interest
W_z	Estimated non-irrigated withdrawals for a known year following the year of interest
Y_t	Year of interest
Y_a	Year of available data prior to the year of interest
Y_z	Year of available data following the year of interest

Initially, the USGS industrial withdrawals estimate was considered as the benchmark for comparisons. However, the USGS water use circulars do not always have a consistent format from publication to publication, and some categories have been eliminated and/or combined to form other categories. This appears to have been the case for industries that use a municipal source. Occasionally, withdrawal estimates obtained for a single industry within the DNR survey data exceeded the annual self-supplied industrial water use estimates in the USGS circular. Because of these circumstances, non-irrigation withdrawal values were developed instead.

These estimates were derived by removing the major source of withdrawals (irrigation) from total USGS county withdrawal estimates. Having estimated the county's non-irrigation withdrawal, the proportion of non-irrigation withdrawals associated with a given industry was determined for each year in which industry withdrawal data were available. These annual proportions were then averaged across all years of available records. This average proportion was then used to estimate annual pumping volumes for each unknown year in the period of interest by multiplying that fraction by the USGS non-irrigation withdrawal value for each year with missing data. The final step was to distribute the annual value to monthly values, which was done by using the average monthly distribution.

The self-supplied industrial withdrawals were geospatially referenced by assigning those values to the COHYST cells where their wells were located. If an industry acquired its water from a municipal supply, the industrial withdrawals were applied to the cell representing the centroid of the municipality. Several municipalities contained multiple industrial sites, in which case the withdrawal values were simply summed and applied to that location.

Estimating Discharge

When discharge values were present in conjunction with the withdrawal values, the annual ratio of discharge to withdrawals was computed. The average relationship was then applied to the years when no annual estimates or values were present, by multiplying the annual withdrawals by this average ratio. This process was undertaken to approximate the annual discharge in unknown years, including years where the withdrawals were estimated. Once the annual amounts had been estimated they were partitioned using the average monthly discharge proportion of total discharge.

Some industry sites included only annual values or estimates. If there were industries that served the same purposes (i.e. two alfalfa pelleting plants) and only one of them had monthly values, the monthly distributions for that industry were applied to the industry that included only annual values. Otherwise the withdrawals or discharges were spread uniformly across the year.

The discharge values were assigned to the COHYST cell that contained the location of discharge, but only if the industry had a known discharge location into a stream. If no discharge locations were identified, it was assumed that the industry had a zero-discharge facility.

Municipal Data and Estimates

Municipal withdrawals and discharges were acquired for 36 communities and estimated for an additional 12 communities in the COHYST model area. Monthly withdrawal and/or discharge data were provided by the Twin Platte NRD, Central Platte NRD, and the Tri-Basin NRD. Supplemental discharge data were acquired from the DEQ DMRs.

Municipal pumping estimates were heavily dependent on the size of the municipal population. Population estimates supplied by the DNR for the years 1994-1999 and 2005 were combined with data from the U.S. Census Bureau from 1980, 1990, 2000, and 2010 to estimate the population for each year during the investigation period. Linear interpolation between two known annual population values was used between the known data points.

Once the population was estimated, the per capita withdrawals or discharges were calculated on a monthly basis for the years with available data. For years with missing data, a moving average of the previously calculated per capita withdrawals or discharges was used to calculate the monthly withdrawal or discharge by multiplying the moving average with the estimated population.

$$\widetilde{W}_{m,y} = \frac{P_y \sum_k C_{m,k}}{n}$$

$\widetilde{W}_{m,y}$	Estimated withdrawal or discharge for the municipality for a given month and year.
$C_{m,k}$	Per Capita withdrawals for a given month (m) and year (k).
P_y	Estimated Population of the municipality during a given year y
n	Number of years in the moving average. An 8 year moving average was used except for those cases with less than 8 years of available data.
m	The month being estimated
k	The years being used in the moving average (n years total).

The next step was to remove the municipally supplied industrial withdrawals from the municipal withdrawals, which was done on a city-by-city basis. Lexington, NE, municipal withdrawals were approximately half of the withdrawals used by Tyson Fresh Meats, the largest industrial user. While the Tyson Fresh Meats water use survey from DNR states that Tyson's water source was from the municipal supply, it was assumed that the industrial withdrawals have already been removed from the municipal withdrawals in Lexington. The municipal withdrawals were then assigned to the COHYST cell containing the centroid of the municipality.

Estimating discharge when no data were present

If no discharge data were available, the annual discharge was estimated as a proportion of withdrawals. The proportion used was calculated in different ways, depending upon the population of the municipality. For municipalities smaller than 1,500, between 1,500 and 10,000, and greater than 10,000, ratios of .341, 0.438, and 0.630 were used to estimate discharge, respectively.

The annual discharge was then distributed by using distributions calculated for other nearby municipalities or municipalities with similar populations. For each town that lacked discharge data, the average monthly discharge distribution for the four closest towns was compared to the average monthly discharge distribution of the four towns with similar population size regardless of location (with the caveat that the towns used to calculate the averages needed to have discharge data available). The difference between these two discharge distribution estimates was rarely greater than 1%, and often below 0.5%. With this in consideration, estimates were made using the distribution of similar sized towns.

Blank values for partial years were estimated using the same procedure explained for the industries. If only the annual amount was reported, it was distributed according to the average distribution based upon municipalities of similar size.

Discharge values were assigned to the COHYST cell at the location where the municipality discharged into a stream. For municipal discharges with no known discharge locations, it was assumed that they employed zero-discharge wastewater facilities.

Domestic Self-Supplied Withdrawal Estimates

Self-supplied domestic withdrawals were calculated based upon the USGS water use circulars published in 1985, 1990, 1995, 2000, and 2005. A value for 2010 was estimated using either 1) the average over the period 1985-2005 if there were sigmoidal fluctuations (Figure 1) every five years or 2) a linear regression model if there was a persistent rise (Figure 2) or decline in the withdrawal rate. Withdrawal rates for years between USGS circulars were estimated using linear interpolation. The monthly distribution developed for a municipality with a population less than 1,500 residents was used to partition the annual withdrawals into monthly values.

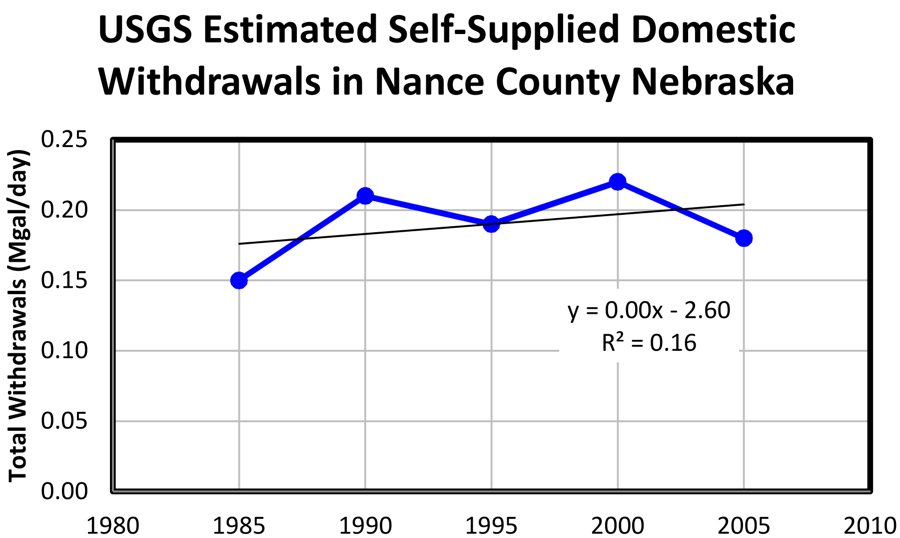


Figure 1. Fluctuating self-supplied domestic withdrawals in Nance County, Nebraska.

A list of all domestic wells with their geographic location was acquired from the DNR registered groundwater well database. The monthly self-supplied domestic withdrawal values were then assigned to the COHYST cells based upon the number of wells present in each cell. A uniform quantity of water withdrawals was assigned to each well and the cumulative amount was assigned to the cell. This process was done for 32 counties wholly or partially contained in the middle and eastern sections of the COHYST model area.

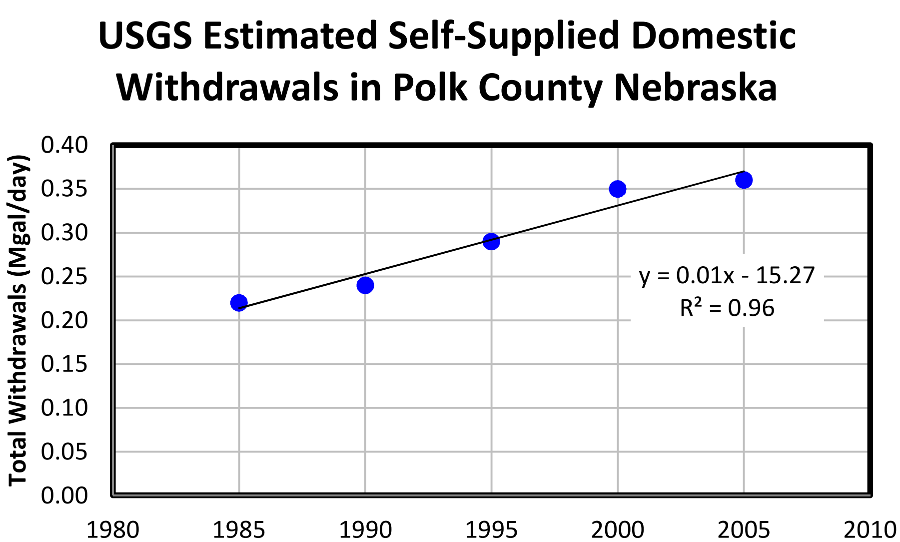


Figure 2. Upward trending self-supplied domestic withdrawals in Polk County, Nebraska.

The maximum level of withdrawals in any given cell was 275,000 gallon pumped in a single month. This occurred during January, 2005, in cell 85066, which was located in Hall County, Nebraska, and contains 49 domestic wells. If the pumps were run 24 hours a day for the entire month, the combined capacity of the 49 wells would need to be less than 6.4 gpm, or 0.13 gpm per well. Assuming the wells were active a quarter of the time, the combined capacities of the well would need to be 25.5 gpm, or 0.52 gpm per well. These values appear to be within the pumping capabilities for a typical domestic well.

Municipal and Industrial Pumping

Prepared By:
The Flatwater Group, Inc

1. Introduction

1.1. Authorization

The Flatwater Group, Inc. (TFG) has prepared this as authorized in the contract between the Nebraska Department of Natural Resources (DNR) and TFG originally dated 9 August 2010.

1.2. Purpose and Scope

Municipal and industrial (M&I) pumping is a small but significant element crucial to the acumen of a robust conjunctive management model. While not encompassing as much spatial area as other parts of the Regionalized Soil Water Balance model (RSWB); the impact of M&I pumping can be substantial in localized area. The M&I development process is shown in figure 1.

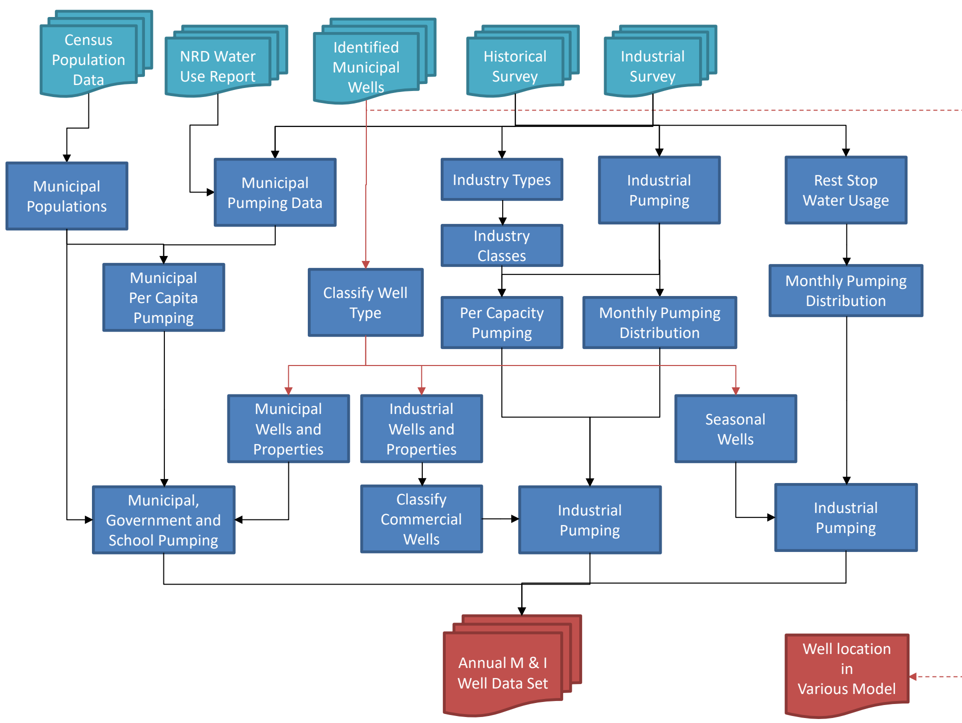


Figure 1. The development process for the M&I state-wide data set.

TFG received a statewide shapefile of registered groundwater wells designated as either Commercial (C) or Public (P or U) from the Nebraska Department of Natural Resources (NDNR). The process to develop the industrial and municipal withdrawals included drawing on data from multiple sources. The Department of Natural Resources (DNR) and the natural resource districts (NRDs) in the COHYST model area (Central Platte NRD, Tri-Basin NRD, Twin Platte NRD) provided pumping measurements and estimates; and additionally the spatial location of the wells. United States Census Bureau data was downloaded from the Nebraska Department of Economic Development website.

DNR circulated two types of water use surveys to industries throughout the COHYST model area. The first type was title “Historical Surveys”. Information contained in the surveys includes the industry type, monthly and or annual pumping, and the technique used to acquire the data (metered or estimated). Many of the industries surveyed received their water source from municipal water supplies; however, this information provided valuable insight into the volume of water that was withdrawn by the industry.

A second type of water use survey was sent to owners of registered industrial wells; "Industrial Surveys". The survey included a list of wells used at an industrial location; with the request for information on all pumping from any other wells supplying water to the industry. Additionally, the survey requested information on the type of industry, well properties, and the technique used to arrive at the reported pumping totals.

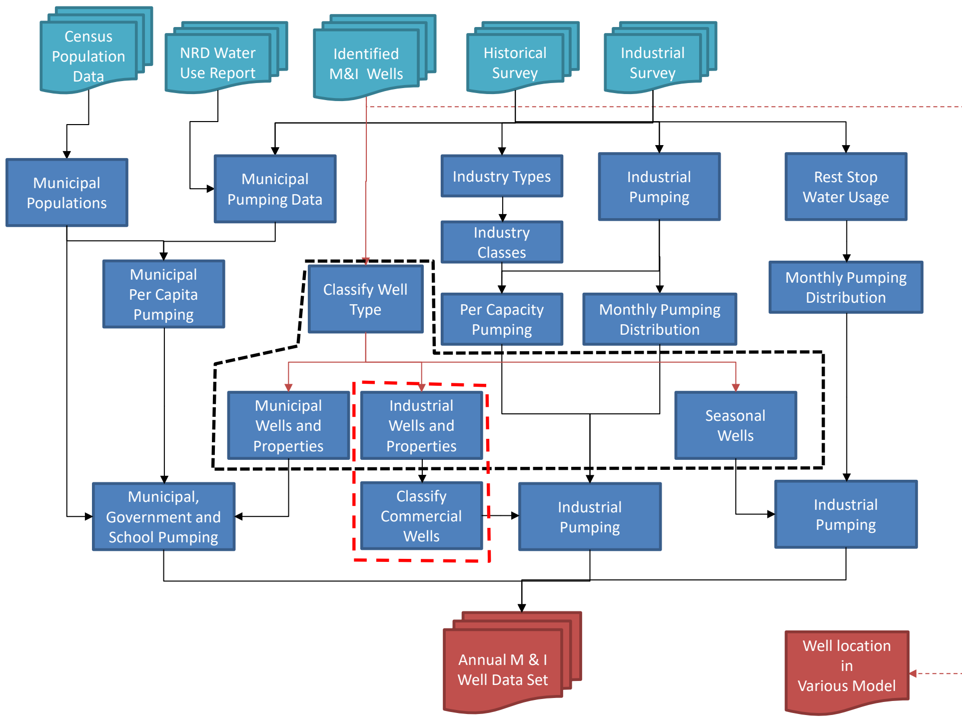
The inclusion of municipal pumping information in either the industrial or historical surveys was sparse. To supplement this limited information, data used in the development of the 2010 NRD water use reports from the TPNRD, CPNRD, and TBNRD was incorporated into the development of the M&I pumping data set.

The populations of the municipalities were acquired from the US Census Bureau for the years 1930-2010.

The statewide well coverage was overlaid with the 6 water basin model grids individually as well as the statewide model grid to determine the grid cells each well resided within. This tabular data was imported into a database where it is combined with the population data based on municipality. The total well capacity of a municipality is calculated to be used in the distribution process. A separate municipal well capacity is also calculate based on the model grid which the wells are located in. For instance, if a municipality has several wells located in one model grid and others located within another model grid, a separate capacity is calculated for each group of wells and associated with the appropriated model grid id.

This data was used in various forms to develop three different datasets depicting pumping estimates from municipalities and industries based upon the characteristics of the well and the type of industry using the well.

2. Well Classification



The first step was to classify all of the identified wells. Six different types of wells were readily identifiable based upon the owner of the well; public, commercial, seasonal, governmental, public interest, and educational.

- Public wells were defined as those wells that fed the municipalities.
- Commercial wells were owned by individual or companies whose was deemed as neither agricultural nor domestic in use. Examples included private business, power production facilities, golf courses, etc…
- The seasonal classification consisted of wells that provided water for items such as campgrounds or the Nebraska Game and Parks Commission.
- The governmental class includes wells for governmental services associated with public safety. These items include prisons, military installations, and law enforcement centers.
- Public Interest well mainly consisted of wells to meet the needs of the travellers and transportation. These wells included those owned by the Nebraska Department of Roads and the wells used to operate rest stops.
- Educational wells were wells that were owned by school districts or institutions of high learning.

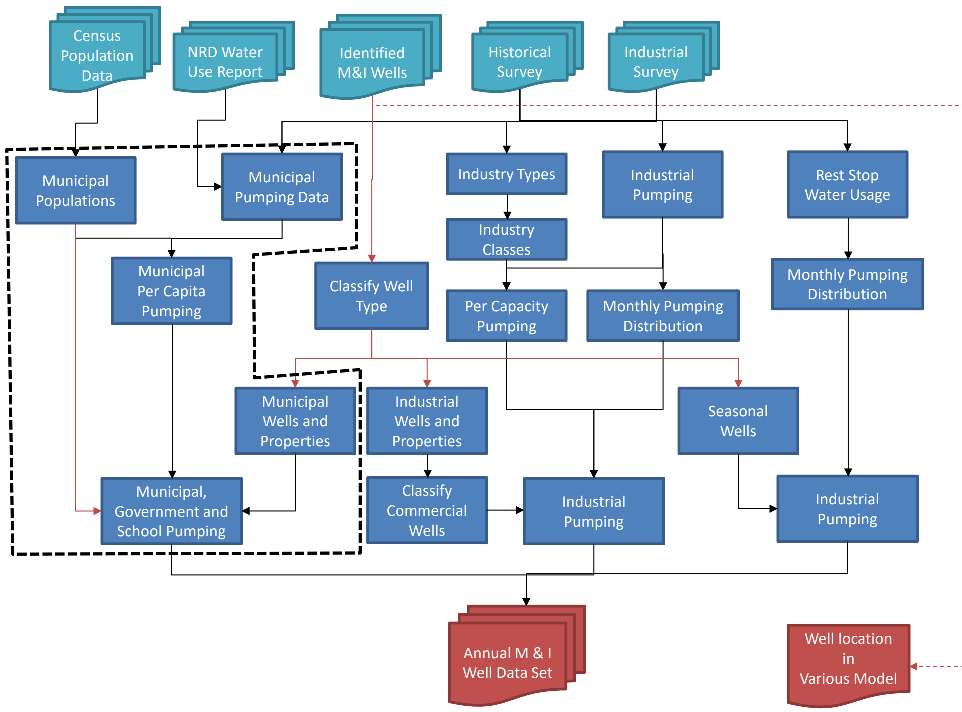
Unfortunately, this level of classification was not sufficient to match the well information with the available information from the data sources. To account for this these classes were further combined into three groups.

The educational and the governmental wells were combined with the public wells to form the municipal well group. Data limitations failed to provided enough information to independently develop estimates for the water usage by the entities described in the governmental or educational well classes. However, the presences of similar entities potentially exist within the constructs of the users of the public wells used to develop municipal pumping estimates.

Seasonal and public interest wells were combined as they were both deemed dependent upon the number of users with small amounts of net consumptive use.

The commercial wells are the only group included in the industrial well data set.

3. The Estimation of Municipal Pumping



The estimated pumping for municipal, governmental, and educational wells was developed using a per capita pumping values for the municipality to which the well belongs. By interpolating between the decadal populations retrieved from the 10 year census, an annual population was developed. The population in 2011-2012 was the product of extrapolating each town's population trend between 2000 and 2010.

$$pop_i = pop_1 + (pop_2 - pop_1)\left(\frac{year_i - year_1}{year_2 - year_1}\right)$$

pop	population
year	year
i	pertaining to the estimated year
1	first interpolating/extrapolating point
1	second interpolating/extrapolating point

Next, the municipal pumping data was organized by municipality. Using the annual population estimates, the per capita pumping was determined by dividing each monthly pumping value by the annual population. An average per capita pumping for each month was taken over the period of available pumping data. This process was repeated for each municipality. The list of municipalities is shown located in Appendix A.

An average monthly per capacity pumping distribution was developed for three groups based upon population. These however, did not differ significantly from a simple average over the entire set of municipalities. Therefore, the single average monthly per capita pumping distribution was utilized. The distribution is shown in Table 1.

Table 1. Monthly Per Capita Pumping

Month	Per Capita Pumping (Mgal/person)
Jan	0.0053
Feb	0.0048
Mar	0.0057
Apr	0.0066
May	0.0095
Jun	0.0119
Jul	0.0161
Aug	0.0134
Sep	0.0110
Oct	0.0079
Nov	0.0057
Dec	0.0054

Having developed the monthly per capita pumping distribution and annual population estimates, the total volume of water pumped by the municipality can be estimated. This amount is then split between all active wells feeding the municipality, weighted by the relative capacity of the well.

$$P_{well,i} = Pop_j * P_{pc,i} * \frac{Cap_{well}}{Cap_{muni,j}}$$

$P_{well,i}$ Pumping for the well in month i

Pop_j Population for the municipality in Year j

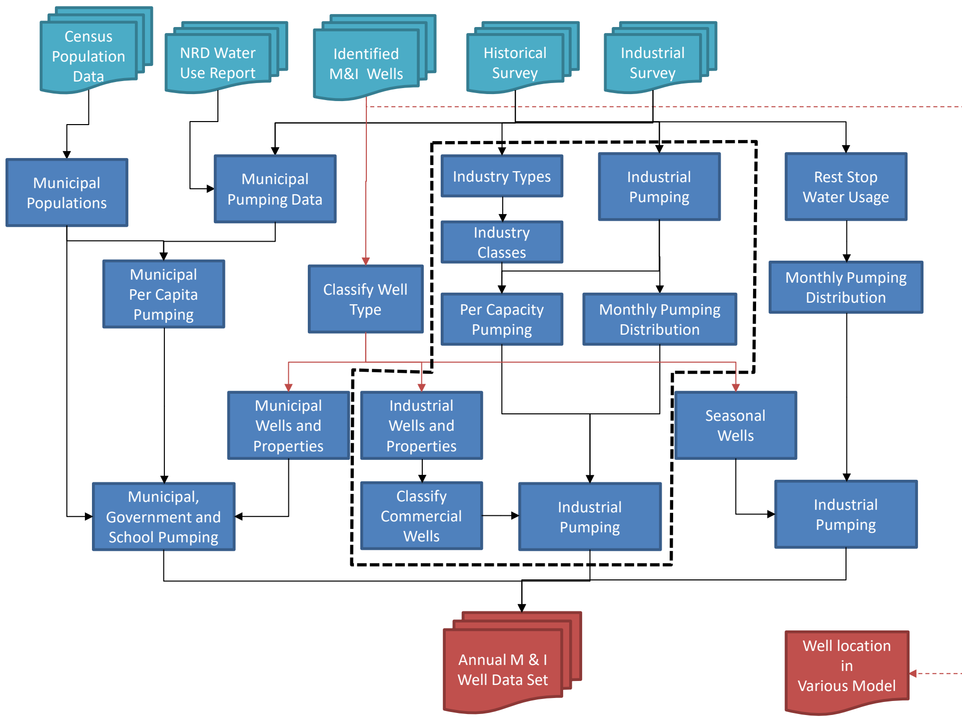
$P_{pc,i}$ Pumping per capita in month i

Cap_{well} Capacity of the well

$Cap_{muni,j}$ Total capacity of the municipality in year j

The towns of Yankton, SD; Julesburg, CO; and Bern, KS all had water sources within the state of Nebraska. However, total pumping capabilities for these municipalities was unknown. Therefore, the populations were adjusted to 10%, 25%, and 25% respectively.

4. The Estimation of Industrial Pumping



Using the data collected by DNR in the Historical and Industrial Surveys, the following technique was developed to estimate industrial pumping volumes for the state-wide M&I dataset. The survey results provided water use information for 50 different industrial sites. The average annual volume of water usage and the average monthly pumping distribution were compiled for each industrial site. Also, when available the pumping capacity of the individual industry was obtained. This information was augmented with data relating to the industry from the Nebraska Well Registry.

The next step was to create and assigned different industrial categories to group similar types of water users. Twelve different classes were developed. Additionally two large water users, Western Sugar Cooperative and the Sutherland coal power plant, remained as unique groups. The different industrial classes are:

1. Western Sugar Cooperative
2. Ethanol Production
3. Golf Courses
4. Meat Packing and Animal Byproduct Manufacturing
5. Sand and Gravel
6. Confined Animal Feeding Operations (CAFO)
7. Construction
8. Power Plants

9. Small Manufacturing
10. Medium Manufacturing
11. Large Manufacturing
12. Small Business
13. Raceways
14. The Sutherland Coal Power Plant

As with any water user, even within an industry, the amount of water that is consumed varies for several reasons including: size, product, etc... Therefore, a technique was developed to estimate the per capacity annual pumping for each defined industrial class. This was accomplished first by determining the average annual volume of water used for each industrial class. Next the average total capacity per industrial class was computed. The industrial class per capacity pumping was the result of dividing the average industrial pumping by the average industrial capacity.

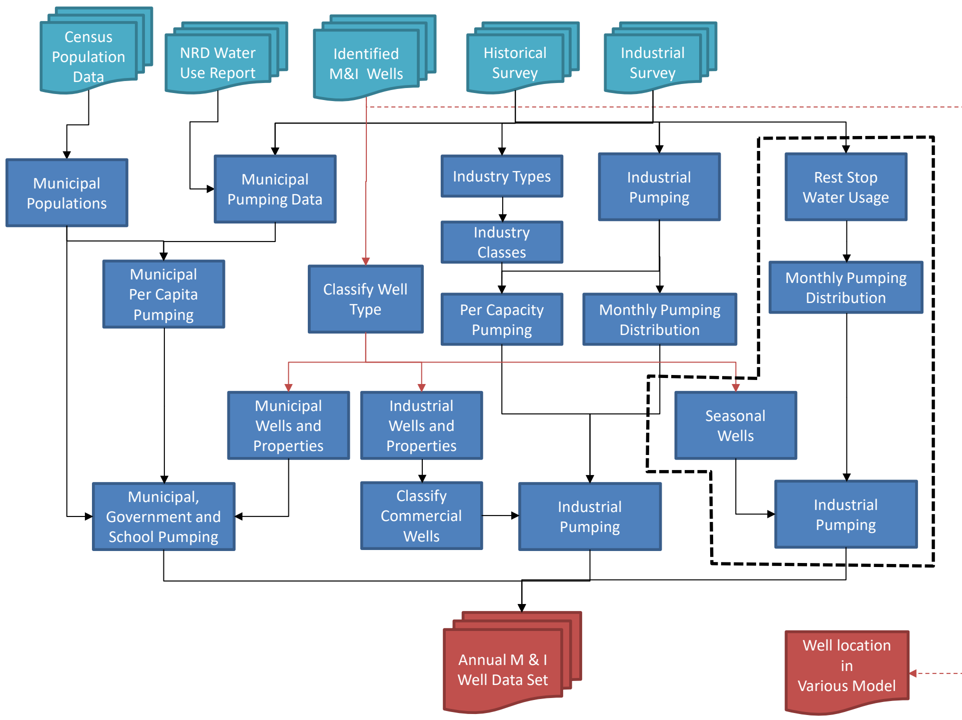
Finally the monthly distribution for each industry class was determined by averaging the distribution for each industry. Two exceptions existed, CAFO and power plant. All CAFOs reported that they were using the same volume of water throughout the year. Therefore, the CAFO water use was evenly distributed between the months. The power plant monthly distribution was developed using the monthly power production distribution from US Energy Information Administration for 2011-2012.

The next step was to assign the various industries within the well file to the corresponding industrial class. A short internet search was performed on each individual company. The results were used to classify the company to the correct group. Unfortunately, the sample of industries in the historical and industrial surveys was not sufficient to cover all types of industries within the state. Therefore, some rules were developed to classify the remaining businesses.

- Mining and Fossil Fuel extraction was classified as large industrial
- Agriculture production types were classified as golf course (nurseries, vegetable, etc…)
- Well drilling was classified with sand and gravel
- Game and Parks wells were classified as golf courses
- Unknown Business types were classified by total well capacity (gpm):
    - 0 – 350 small business
    - 350 – 600 small manufacturing
    - 600 – 1250 medium manufacturing
    - 1250 + large manufacturing

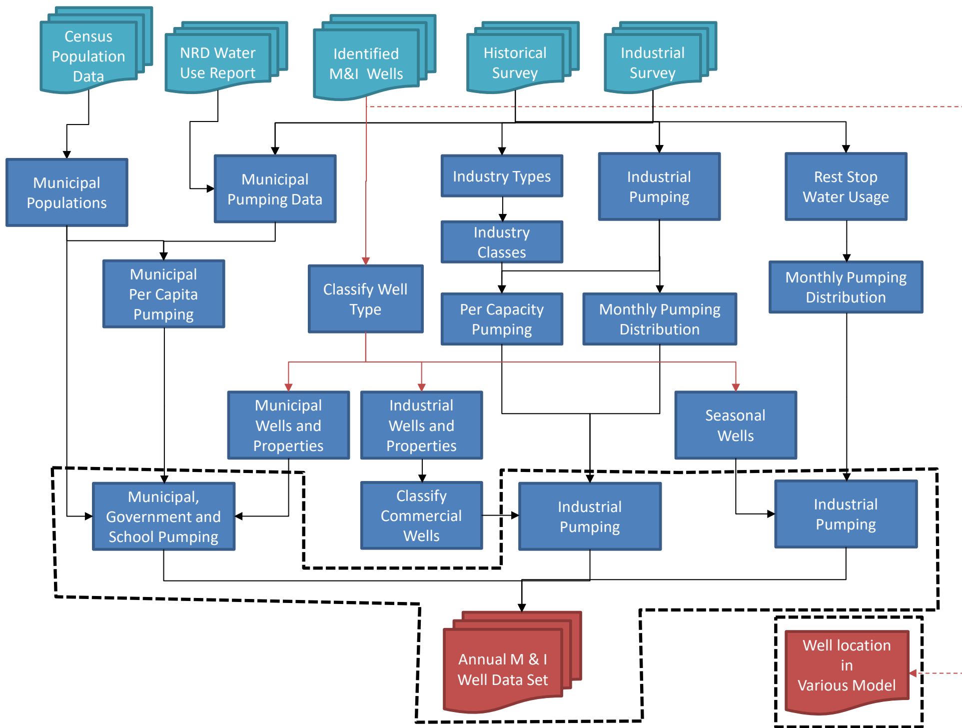
The appropriate per capacity pumping and monthly distribution was applied to each well to develop the industrial pumping data set from industrial wells.

5. The Estimation of Seasonal Industrial Pumping



The seasonal industrial pumping data set was developed based upon the results of the Rest Stop Water Usage from the Industrial Survey. The rest stop water data was developed based upon the per visitor water usage, with each visitor using 2.5 gal. The total monthly water usage was estimated for each rest area in the sample population. The monthly average over all sample rest areas was used to define the monthly pumping distribution for the seasonal industrial wells. The distribution was then applied to all seasonal wells to create the Seasonal Industrial Pumping data set.

6. Process Results



The results from the municipal pumping, industrial pumping, and seasonal industrial pumping are compiled to create the Annual M&I state wide data base. This file contains the well, the years and the volume of pumping that occurs from the well each month.

The Annual M&I state wide data base is to be used in combination with the well location file. The well location file contains the model cell ID for each RSWB model and the state-wide grid; Western Water Use Model (WWUM), Upper Niobrara White Model (UNW), the Central Nebraska Model (CNEB), the Blue Basin Model (BBM), COHYST, and the Missouri Tribs; in which the well is located.

Appendix A

The municipalities used to create the per capita pumping distribution are listed in Table A.1. Each month contains the average per capita pumping for each town over the time period when pumping records were available. The average population is also depicted over this same time period.

Table A.1. Municipality average per capita pumping values used to create the municipal per capita pumping distribution.

#	city	Ave Pop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Brady	396	0.005	0.006	0.005	0.007	0.014	0.017	0.028	0.022	0.016	0.009	0.005	0.005
2	Brule	367	0.005	0.004	0.004	0.006	0.010	0.013	0.016	0.014	0.010	0.006	0.004	0.005
3	Maxwell	311	0.004	0.004	0.005	0.005	0.006	0.009	0.010	0.008	0.005	0.005	0.003	0.004
4	Ogallala	4771	0.004	0.003	0.004	0.005	0.009	0.010	0.013	0.012	0.009	0.005	0.004	0.003
5	Paxton	554	0.004	0.004	0.005	0.006	0.009	0.010	0.014	0.014	0.010	0.007	0.005	0.004
6	Sutherland	1223	0.005	0.005	0.006	0.006	0.007	0.010	0.012	0.012	0.011	0.007	0.005	0.005
7	North Platte	24097	0.005	0.005	0.005	0.007	0.009	0.012	0.014	0.014	0.012	0.009	0.005	0.005
8	Axtell	711	0.005	0.004	0.005	0.006	0.009	0.012	0.019	0.015	0.011	0.008	0.005	0.005
9	Bertrand	778	0.005	0.005	0.005	0.007	0.012	0.014	0.024	0.017	0.015	0.009	0.006	0.005
10	Elwood	720	0.006	0.005	0.006	0.008	0.011	0.013	0.017	0.015	0.012	0.009	0.007	0.006
11	Funk	194	0.011	0.007	0.010	0.008	0.005	0.011	0.014	0.013	0.014	0.013	0.006	0.011
12	Loomis	382	0.004	0.005	0.005	0.008	0.014	0.020	0.029	0.021	0.016	0.008	0.005	0.004
13	Smithfield	62	0.004	0.004	0.005	0.005	0.007	0.008	0.012	0.012	0.010	0.012	0.005	0.005
14	Alda	631	0.004	0.004	0.004	0.004	0.007	0.010	0.012	0.010	0.008	0.005	0.004	0.004
15	Amherst	257	0.010	0.009	0.011	0.013	0.015	0.020	0.027	0.020	0.021	0.020	0.012	0.012
16	Cairo	786	0.004	0.004	0.004	0.005	0.008	0.010	0.015	0.012	0.009	0.006	0.004	0.004
17	Central City	2929	0.005	0.006	0.006	0.007	0.010	0.010	0.010	0.014	0.011	0.010	0.009	0.009
18	Cozad	4185	0.006	0.006	0.017	0.009	0.014	0.018	0.023	0.018	0.015	0.009	0.006	0.006
19	Doniphan	773	0.006	0.006	0.006	0.007	0.009	0.013	0.018	0.014	0.012	0.008	0.006	0.006
20	Duncan	346	0.006	0.003	0.003	0.009	0.012	0.010	0.011	0.009	0.007	0.005	0.003	0.003
21	Elm Creek	873	0.006	0.005	0.006	0.007	0.011	0.014	0.020	0.015	0.013	0.008	0.006	0.006
22	Eustis	427	0.006	0.005	0.005	0.008	0.014	0.018	0.025	0.019	0.017	0.010	0.006	0.005

#	city	Ave Pop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
23	Farnam	213	0.004	0.004	0.004	0.005	0.007	0.009	0.013	0.013	0.011	0.007	0.006	0.006
24	Gibbon	1785	0.006	0.005	0.006	0.006	0.005	0.009	0.011	0.009	0.008	0.008	0.007	0.004
25	Grand Island	44164	0.008	0.007	0.008	0.008	0.011	0.013	0.017	0.015	0.012	0.010	0.008	0.008
26	Gothenburg	3606	0.005	0.005	0.006	0.008	0.012	0.014	0.019	0.016	0.013	0.009	0.006	0.005
27	Kearney	28722	0.004	0.004	0.004	0.005	0.007	0.009	0.012	0.010	0.009	0.006	0.005	0.004
28	Lexington	9840	0.005	0.004	0.006	0.006	0.010	0.010	0.013	0.010	0.008	0.006	0.005	0.005
29	Overton	650	0.002	0.003	0.003	0.004	0.005	0.005	0.007	0.005	0.003	0.003	0.002	0.002
30	Riverdale	206	0.004	0.004	0.004	0.005	0.007	0.009	0.011	0.008	0.006	0.005	0.013	0.004
31	Shelton	1085	0.005	0.004	0.004	0.005	0.007	0.008	0.013	0.011	0.008	0.006	0.004	0.004
32	Wood River	1217	0.005	0.005	0.006	0.007	0.009	0.012	0.015	0.013	0.011	0.007	0.005	0.005

Appendix B

The list of industries from the historical or industrial surveys used to create the industrial classes and their distributions are shown in Table B.1.

Table B.1. Industrial sites used to create the industrial pumping data.

#	Name	Industrial Class
1	Gothenburg Feed Products Co	10
2	Chief Fabrication	10
3	Chief Buildings	10
4	Chief Agri Industrial	10
5	Chief Custom Products	10
6	Chief Automotive Systems Inc	12
7	Tyson Fresh Meats, Inc.	4
8	Diamond Plastics Corp	10
9	Pennington Seed, Inc	9
10	Consolidated Concrete, Co	5
11	Masonite Internatinoal Corp	9
12	Eilers Machine and Welding	9
13	L & S Industries, Inc	9
14	G Tech, Inc	9
15	Archer Daniels Midland Co.	9
16	Dy-NA Tool & Mold, Inc	10
17	Sutherland Industries	12
18	Monroe Auto Equipment Co	10
19	Consolidated Blenders Inc.	5
20	Island Dehy Co Inc.	10
21	Hornady Manufacturing Company	11
22	Orthman Manufacturing, Inc	9
23	West Company Inc.	11
24	Veetronix, Inc.	12
25	Electronic Display Systems	9
26	Baldwin Filters, Inc	10
27	Baldwin Filters	11
28	Big Flag Farm Supply Inc.	12
29	Western Sugar Cooperative	1
30	Werner	5
31	Wood Drive Dairy	6
32	Werner Construction	7
33	US 30 Speedway, LLC	13
34	KCC Feeding Inc.	6

#	Name	Industrial Class
35	Brown Sheep Company Inc	10
36	Alma Golf Course	3
37	Procter & Gamble	11
38	Nebraska Public Power District	8
39	Philips - Golf Course	3
40	Halimage Farms LLC	6
41	Nebraska Energy LLC	2
42	Agriculture Services Inc	10
43	Simon Contractors	5
44	Petersons Supermarket	12
45	Nitro Construction	7
46	Abengoa Bioenergy	2
47	Gibbon Packing Inc	4
48	Island Land Handlers	5
49	Nutra-Flo Company	10
50	Miscellaneous Ethanol Plant*	2

*By request of the ownership and to protect trade secrets, this name is being withheld from publication.

Appendix C

The list of industrial classes is shown in Table C.1. The table includes the average class annual pumping, the average class per capacity pumping, and the average portion of the annual pumping that occurs during each month.

#	Industrial Class	Annual Pumping (Mgal)	Per Capacity Pumping (gal/gpm)	Average Distribution of Annual Pumping											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Western Sugar Cooperative	1,463.786	221,786	0.107	0.084	0.096	0.055	0.038	0.037	0.050	0.063	0.081	0.142	0.120	0.126
2	Ethanol	311.029	112,150	0.083	0.073	0.080	0.082	0.083	0.084	0.091	0.087	0.085	0.090	0.081	0.081
3	Golf Course	17.390	53,922	-	-	0.038	0.066	0.085	0.094	0.131	0.192	0.178	0.160	0.056	-
4	Meat Packing and Animal ByProducts	614.104	372,185	0.081	0.079	0.084	0.074	0.081	0.088	0.085	0.093	0.087	0.084	0.083	0.080
5	Sand and Gravel	29.450	26,652	0.051	0.051	0.058	0.074	0.092	0.099	0.095	0.102	0.147	0.098	0.076	0.058
6	CAFO	39.541	36,111	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
7	Construction	0.110	109	-	-	0.044	0.108	0.108	0.216	0.201	0.137	0.137	0.049	-	-
8	Power Plant	6.760	193,143	0.084	0.084	0.080	0.089	0.098	0.112	0.108	0.090	0.083	0.082	0.090	-
9	Small Manufacturing	0.426	2,131	0.087	0.087	0.077	0.068	0.074	0.082	0.079	0.086	0.091	0.083	0.079	0.107
10	Medium Manufacturing	3.057	1,703	0.053	0.054	0.076	0.058	0.069	0.123	0.121	0.103	0.124	0.077	0.064	0.078
11	Large Manufacturing	78.822	43,912	0.093	0.090	0.095	0.077	0.076	0.077	0.079	0.082	0.080	0.083	0.080	0.088
12	Small Business	0.233	4,673	0.023	0.021	0.021	0.027	0.050	0.093	0.117	0.172	0.149	0.144	0.119	0.065
13	Raceway	0.120	400	-	-	0.038	0.066	0.085	0.094	0.131	0.192	0.178	0.160	0.056	-
14	Sutherland Power Plant	4,353.780	72,989	0.084	0.084	0.080	0.089	0.098	0.112	0.108	0.090	0.083	0.082	0.090	-

Appendix D

The seasonal industrial pumping is dependent upon the rest stop water use. The rest stops listed in Table D.1. were included in the development of the rest stop pumping distribution.

Table D.1. Rest stops included in the creation of the seasonal pumping distribution.

Station	County	City
Melia Hill	Sarpy	Gretna
Platte River	Cass	Greenwood
Lincoln Solar	Lancaster	Lincoln
York WB	York	York
York EB	York	York
Grand Island WB	Hall	Grand Island
Grand Island EB	Hall	Grand Island
Sutherland WB	Lincoln	Sutherland
Sutherland EB	Lincoln	Sutherland
Brady WB	Lincoln	Brady
Brady EB	Lincoln	Brady
Chappell WB	Duel	Chappell
Chappell EB	Duel	Chappell
Sidney WB	Cheyenne	Sidney
Sidney EB	Cheyenne	Sidney
Kimball EB	Kimball	Kimball
Kimball WB	Kimball	Kimball
Ogallala EB	Keith	Ogallala
Ogallala WB	Keith	Ogallala
Cozad EB	Dawson	Cozad
Cozad WB	Dawson	Cozad
Kearney EB	Buffalo	Kearney
Kearney WB	Buffalo	Kearney
Goehner WB	Seward	Goehner
Blue River EB	Seward	Milford

Table D.2. Monthly distribution of seasonal industrial pumping.

Mon	Pumping (gal)
Jan	30,799
Feb	29,426
Mar	43,174
Apr	48,037
May	61,025
Jun	69,021
Jul	84,227
Aug	65,488
Sep	57,772
Oct	54,188
Nov	44,495
Dec	37,589

Memorandum

To:	Ann Dimmitt – TPNRD; Kari Burgert – NDNR
From:	The Flatwater Group, Inc.
CC:	Michael Krondak - NPPD
Date:	10/22/2018
Subject:	COHYST Area Robust Review: Gerald Gentleman Station M&I Pumping

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document changes to the Municipal and Industrial (M&I) Pumping at the Gerald Gentleman Station (GGS) within the Twin Plate NRD (TPNRD).

TFG's primary task was to modify the GGS M&I pumping by replacing the estimated GGS pumping developed as part of the Statewide M&I efforts[1] with the values from the Nebraska Public Power District (NPPD) annual reports to NDNR. The new M&I data sets are to be used in the Robust Review Scenarios.

Data Collection

TPNRD and TFG reached out to NPPD, who provided TFG with the monthly pumping volumes from 2005 forward. NPPD provided three files:

1. GGS Industrial Well Report for 2013.pdf
2. GGS Industrial Well Report for 2012.pdf
3. Historical GGS Well Field Monthly pumping from Isaac Mortensen modeling.xlsx

The GGS pumping is divided between two well fields. One well field (Well Field 1) is used to meet the plant operation needs. Well field 1 is comprised of 5 wells, but unmetered. The pumping for the Well Field 1 was estimated by NPPD based upon their typical annual usage. This amounted to 873 AF/year. The pumping was split evenly throughout the year based upon NPPD's description of typical usage.

The second well field (Well Field 2) is part of the cooling water system. Well Field 2 has 38 wells, of which 27 are currently being utilized. Monthly pumping volumes for Well Field 2 were provided from commencement of operations in 2005 through 2013 (Table 1). To project the M&I pumping into the future, an average of the last 6 years of reported data was used[2].

To estimate the net effect operation of the Well Field 1 & 2 have on the aquifer, it was assumed that 50% of the total pumping was consumed with the other 50% returning eventually to the aquifer. This

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[1] Details on the Statewide M&I efforts are documented in: ftp://dnrftp.dnr.ne.gov/Pub/INSIGHTDocumentation/2015/DataAndDocumentation/AdditionalBackUpData/MunicipalAndIndustrialPumping/MunicipalAndIndustrialPumping_TFG2014.pdf

[2] The initial GGS pumping estimates were based upon the M&I Survey performed by NDNR. NPPD provided pumping volumes for the years 2005-2007 for that survey. The 6-year average was used to reflect more current operating procedures.

assumption is consistent with the approach taken in developing the Statewide M&I dataset. This assumption was incorporated by applying a multiplier of 0.5 to the estimates of total pumping discussed above. This yielded 436.5 AF/year from Well Field 1, while the net pumping estimates from Well Field 2 are shown in Table 2.

Table 1. GGS Well Field 2 reported pumping volumes.

Year	Annual Pumping	January	February	March	April	May	June	July	August	September	October	November	December
2005	4,210.9	-	-	-	-	-	-	1,551.3	2,165.2	490.7	3.7	-	-
2006	3,442.4	-	-	-	-	1.2	43.4	957.3	2,440.5	-	-	-	-
2007	8,194.0	-	-	-	-	4.0	870.9	1,705.3	5,406.2	207.6	-	-	-
2008	426.1	-	-	-	-	5.2	167.7	94.5	158.7	-	-	-	-
2009	3,241.1	-	-	-	1.0	11.4	1,243.5	1,391.0	587.7	-	6.5	-	-
2010	1,127.0	-	-	-	-	7.1	589.2	530.7	-	-	-	-	-
2011	13.3	-	-	-	-	5.0	1.0	1.0	0.4	5.5	0.4	-	-
2012	47.0	-	-	-	-	5.0	-	13.0	-	-	21.0	8.0	-
2013	116.0	-	-	-	-	-	9.0	-	1.0	100.0	5.0	1.0	-
Projected	828.4	-	-	-	0.2	5.6	335.1	338.4	124.6	17.6	5.5	1.5	-

Table 2. GGS Well Field 2 net M&I pumping volumes.

Year	Annual Pumping	January	February	March	April	May	June	July	August	September	October	November	December
2005	2,105.5	-	-	-	-	-	-	775.7	1,082.6	245.4	1.9	-	-
2006	1,721.2	-	-	-	-	0.6	21.7	478.7	1,220.3	-	-	-	-
2007	4,097.0	-	-	-	-	2.0	435.5	852.7	2,703.1	103.8	-	-	-
2008	213.1	-	-	-	-	2.6	83.9	47.3	79.4	-	-	-	-
2009	1,620.6	-	-	-	0.5	5.7	621.8	695.5	293.9	-	3.3	-	-
2010	563.5	-	-	-	-	3.6	294.6	265.4	-	-	-	-	-
2011	6.7	-	-	-	-	2.5	0.5	0.5	0.2	2.8	0.2	-	-
2012	23.5	-	-	-	-	2.5	-	6.5	-	-	10.5	4.0	-
2013	58.0	-	-	-	-	-	4.5	-	0.5	50.0	2.5	0.5	-
Projected	414.2	-	-	-	0.1	2.8	167.5	169.2	62.3	8.8	2.7	0.8	-

Creation of the new Watershed Model M&I Pumping input files

The new input data sets were developed by beginning with the original COHYST M&I dataset: *MI001*. Returning to the statewide M&I dataset list of industrial well locations, the COHYST model cells containing GGS wells were identified. The M&I pumping within these cells was removed to create the M&I data set: *MIrr_001*[3].

The GGS pumping was used to create a separate M&I dataset: *GGSrr_002*. The GGS well field volumes were split between the individual wells based upon the relative well capacity compared to the total capacity of all actively utilized wells in the respective well field. The pumping was spatially placed in the COHYST model grid using the location of the wells.

Results

By switching from the initial GGS estimates to the reported values, the net pumping for GGS was reduced by ~6,500 AF/year after well field 2 was completed. Total GGS pumping from both well fields in the projected period reduced by just under 7,000 AF/year.

Table 3 provides an overview of the annual M&I pumping used in the first (Baseline 001[4]; Column A) and second (Baseline 002; Columns B-D) iterations of the robust review baseline. The information used for the second iteration of the baseline contains a summary of the GSS pumping (D) and the balance of the COHYST M&I pumping (C). These volumes are combined to arrive at the total M&I pumping (B). Finally, Table 3 continues with a summation of the resultant change in M&I as a result of the changes to the GGS pumping.

Table 3. M&I Pumping in the Robust Review

Year	Baseline 001	Baseline 002			
	(A) M&I Pumping (MI001)	(B) = C + D Total M&I Pumping	(C) M&I Pumping (MIrr_001)	(D) Gerald Gentlemen Station (GGSrr_002)	(E) = B - A Change in M&I Pumping
1950	14,790	14,790	14,790	-	-
1951	14,898	14,898	14,898	-	-
1952	15,183	15,183	15,183	-	-
1953	16,165	16,165	16,165	-	-
1954	17,594	17,594	17,594	-	-
1955	17,824	17,824	17,824	-	-
1956	19,085	19,085	19,085	-	-
1957	19,548	19,548	19,548	-	-
1958	19,736	19,736	19,736	-	-
1959	19,840	19,840	19,840	-	-
1960	20,024	20,024	20,024	-	-
1961	20,756	20,756	20,756	-	-
1962	21,288	21,288	21,288	-	-

[3] TFG checked for additional M&I wells not belonging to GGS in these cells and found none.

[4] The same M&I pumping used in Baseline 001 was also used in the documented COHYST 2010 Run028.

Table 3. M&I Pumping in the Robust Review

Year	Baseline 001 (A) M&I Pumping (MI001)	Baseline 002 (B) = C + D Total M&I Pumping	(C) M&I Pumping (MIrr_001)	(D) Gerald Gentlemen Station (GGSrr_002)	(E) = B - A Change in M&I Pumping
1963	22,498	22,498	22,498	-	-
1964	23,612	23,612	23,612	-	-
1965	24,352	24,352	24,352	-	-
1966	25,042	25,042	25,042	-	-
1967	25,623	25,623	25,623	-	-
1968	26,225	26,225	26,225	-	-
1969	26,693	26,693	26,693	-	-
1970	27,551	27,551	27,551	-	-
1971	27,847	27,847	27,847	-	-
1972	28,873	28,873	28,873	-	-
1973	29,171	29,171	29,171	-	-
1974	29,887	29,947	29,510	437	60
1975	30,812	30,576	30,139	436	(236)
1976	31,955	31,719	31,283	436	(236)
1977	33,029	32,792	32,356	436	(236)
1978	33,345	33,108	32,672	436	(236)
1979	33,635	33,398	32,962	436	(236)
1980	34,061	33,736	33,299	436	(325)
1981	34,437	34,112	33,675	436	(325)
1982	34,720	34,394	33,958	436	(325)
1983	35,120	34,795	34,358	436	(325)
1984	35,265	34,940	34,503	436	(325)
1985	35,339	35,014	34,577	436	(325)
1986	35,400	35,075	34,638	436	(325)
1987	35,903	35,577	35,141	436	(325)
1988	36,433	35,752	35,316	436	(681)
1989	37,291	36,610	36,173	436	(681)
1990	38,155	37,474	37,038	436	(681)
1991	38,528	37,847	37,411	436	(681)
1992	38,867	38,186	37,749	436	(681)
1993	39,253	38,572	38,135	436	(681)
1994	39,880	39,199	38,762	436	(681)
1995	40,850	40,169	39,733	436	(681)
1996	41,239	40,558	40,121	436	(681)
1997	42,001	41,320	40,884	436	(681)
1998	43,068	42,387	41,951	436	(681)

Table 3. M&I Pumping in the Robust Review

Year	Baseline 001 (A) M&I Pumping (MI001)	Baseline 002 (B) = C + D Total M&I Pumping	(C) M&I Pumping (MIrr_001)	(D) Gerald Gentlemen Station (GGSrr_002)	(E) = B - A Change in M&I Pumping
1999	43,547	42,866	42,430	436	(681)
2000	44,177	43,451	43,015	436	(725)
2001	44,606	43,881	43,444	436	(725)
2002	44,786	44,061	43,625	436	(725)
2003	45,564	44,839	44,402	436	(725)
2004	52,490	45,084	44,648	436	(7,406)
2005	53,217	47,916	45,374	2,542	(5,301)
2006	54,051	48,366	46,208	2,158	(5,685)
2007	55,404	52,095	47,561	4,534	(3,309)
2008	55,738	48,544	47,895	649	(7,193)
2009	56,104	50,319	48,262	2,057	(5,786)
2010	56,312	49,469	48,469	1,000	(6,843)
2011	56,494	49,095	48,651	443	(7,399)
2012	56,658	49,276	48,816	460	(7,383)
2013	56,658	49,310	48,816	494	(7,348)
Projected	56,658	49,666	48,816	851	(6,992)

Summary

New M&I pumping data for NPPD's GGS power station was implemented into the Robust Review in the COHYST area. The GGS pumping estimates from the Statewide M&I efforts were replaced with the records from NPPD reports to NDNR. This resulted in a reduction of the average GGS M&I net pumping estimates in the Robust Review of just under 7,000 AF/year for the period after Well Field 2 began operations in 2005.

A.1.5 Memorandums on NRD Land Use Retirements, Transfers and Variances for COHYST2010

Memorandum

To: Tammy Fahrenbruch - Tri-Basin NRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 7/13/2018
Subject: COHYST Area Robust Review: TBNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Nebraska Department of Natural Resources (NDNR) on the COHYST Area Robust Review project. The Robust Review project's purpose is to evaluate the impacts of land use changes to streamflow. To account for transfers, retirements, and variances within TBNRD, TFG's primary work tasks included evaluating and summarizing the transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013 and create a new land use data set for the unretired scenario.

For the first step in the process, TFG worked with NDNR and TBNRD to gather the land use data (retirements, transfers, variances) into summary tables by land use type. After the summary data was organized by land use type, TFG's next step was to perform a geospatial analysis to identify the location of each land use transaction (I.e. retirement, transfer, variance). The geospatial analysis included a proximity function to determine the closest available model cells capable of accommodating land use changes. ArcGIS and custom script were used for the analysis and the results were organized into Tables 11-15

This memo presents summary tables of retirement acres (temporary and permanent) and transferred acres within TBNRD, outlines the spatial analysis methodology, and then summarizes the resultant land use files. Spatial data was provided in shapefile format and spatially analyzed using ArcGIS and custom FORTRAN programs. Land use changes were provided in spreadsheet form; which were analyzed and assimilated by TFG into the COHYST land use files.

Land Use Summary Tables

The Flatwater Group, Inc. (TFG) has compiled a final summary of the retirements, transfers, and variances for the Tri-Basin Natural Resources District (TBNRD) from the information provided by TBNRD and the Nebraska Department of Natural Resources (DNR). This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these land use changes on streamflow as part of the larger Robust Review effort. Table 1 shows an overview summary of retirements and transfers in the TBNRD as provided by TBNRD and DNR. Tables 2-5 show summaries of the individual categories used to create Table 1 and serve as a reference for the description of each of the data sources.

Table 1. Summary of TBNRD acres changes for implementation into the Robust Review.

Year	Temporary Retirements	Reinstated Temporary Retirements	Permanent Retirements	Transfers To	Transfers Away	Change
Baseline Change	(-)	(+)	(-)	(+)	(-)	
1999	1.9	-	-	-	-	(1.9)
2000	293.6	-	-	-	-	(293.6)
2001	408.6	-	-	-	-	(408.6)
2002	-	-	-	-	-	-
2003	-	-	-	-	-	-
2004	77.5	7.0	-	-	-	(70.5)
2005	259.4	-	-	-	-	(259.4)
2006	163.9	-	-	-	-	(163.9)
2007	219.8	-	-	-	-	(219.8)
2008	697.8	77.5	73.1	-	-	(693.4)
2009	167.9	244.7	-	-	-	76.8
2010	127.3	420.5	-	-	-	293.2
2011	111.3	619.4	-	178.7	246.7	440.1
2012	-	413.5	-	118.3	118.3	413.5
2013	-	452.2	-	229.4	245.6	436.0
2014	-	127.3	-	-	-	127.3
2015	-	127.9	-	-	-	127.9
2016	-	-	-	-	-	-
2017	-	39.0	-	-	-	39.0

Table 2. Summary of temporary retirement retired acres in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
1999	-	1.9	-	-	-	-	1.9
2000	-	28.3	7.0	-	258.3	-	293.6
2001	-	-	-	-	408.6	-	408.6
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	77.5	-	-	77.5
2005	-	16.6	21.0	221.8	-	-	259.4
2006	-	-	17.9	116.0	-	30.0	163.9
2007	-	9.0	27.0	183.8	-	-	219.8
2008	126.8	-	13.0	400.5	-	157.5	697.8
2009	-	-	14.8	153.1	-	-	167.9
2010	-	-	-	127.3	-	-	127.3
2011	-	-	-	111.3	-	-	111.3
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

Table 3. Summary of permanent retirement acres in the TBNRD

Year	Conservation Easements	Permanent Retirements
1999	-	-
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	73.1	73.1
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
Total	73.1	73.1

Table 4. Summary of temporary retirement reinstated acres in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
1999	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	7.0	-	-	-	7.0
2005	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-
2008	-	-	-	77.5	-	-	77.5
2009	-	1.9	21.0	221.8	-	-	244.7
2010	-	28.3	17.9	116.0	258.3	-	420.5
2011	-	-	27.0	183.8	408.6	-	619.4
2012	-	-	13.0	400.5	-	-	413.5
2013	126.8	-	14.8	153.1	-	157.5	452.2
2014	-	-	-	127.3	-	-	127.3
2015	-	16.6	-	111.3	-	-	127.9
2016	-	-	-	-	-	-	-
2017	-	9.0	-	-	-	30.0	39.0
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

Table 5. Summary of transfer acres in the TBNRD

Year	Transfer To	Transfer Away	Conversions	Total Transfer Away
2011	178.7	178.7	67.9	246.7
2012	118.3	118.3	-	118.3
2013	229.4	245.6	-	245.6
Total	526.4	542.7	67.9	610.6

The TBNRD provided updated information to TFG in three files on 7/17/2017:

TBNRD AppendixI_Conservation practices.xlsx
Platte_CIA_Permits_Changes_updates.xlsx
Robust_COHYST_Platte_data.xlsx

Within the file *TBNRD Appenidx I_Conservation practices.xlsx* there were several categories of temporary retirements.

Conservation Corners (C Corners SI)

- Robust Review Assignment: Temporary Retirements
- Contract are for 5 years
- 11 entries
- Table 2 & Table 4

Buffer Strips (Buffer Strips)

- Robust Review Assignment: Temporary Retirements
- Contract are for 10 years
- 6 entries
- Table 2 & Table 4

Pheasants Forever (P Forever)

- Robust Review Assignment: Temporary Retirements
- Contract appears to be for 4 years
- 15 entries
- Table 2 & Table 4

Conservation Easements (Cons Easements)

- Robust Review Assignment: Permanent Retirements
- 2 entries
- Table 3

EQIP

- Robust Review Assignment: Temporary Retirements
- Contract appears to be for 4 years
- 95 entries
- Table 2 & Table 4

CREP

- Robust Review Assignment: Temporary Retirement
- 1 entry
- The CREP entry was for 30 acres for the period 2006-2016. This entry was also in the DNR data set. The DNR data set was used due to the accompanying shape file.

From the file *Platte_CIA_Permits_Changes_updates.xlsx*

There were two types of transfers. The first type of transfer involves moving the source of the irrigation water, but the irrigated field remains in the same location. This type of transfer did not require any action to be taken for the robust review. These transfers were listed in the sheets 'G Water Transf_Exsisting' and 'G Water Transfers'.

The second transfer type involves moving the irrigated field to a new location. These transfers were listed in the sheet 'Acres Transfers'. There were 109 records in this sheet. Of these records 25 were incorporated into the robust review. These 25 records were identified to occur in the timeframe that would affect the 2011-2013 irrigation season. This means that the transfer occurred on or after July 1, 2010 and before July 1, 2013. This was based upon the 'Date Approved' field in the table. If the transfer occurred after July 1, it was likely that the original field was still irrigated in the transfer year; as the late year transfers happened in the fall (October-December). While the spring transfers, prior to July 1, had an opportunity to irrigate in the transfer year. Table 6 begins with the same values as the table from Jessie Strom 11/14/2017. The table next illustrates how the transfer acres are split between the record year and the next year based upon the month the transfer took place. Finally, Table 7 show the new distribution of transfer acres which were place in Table 5.

Acres Transfer

- Robust Review Assignment: Transfer Away and Transfer To
- Action is considered permanent
- Contains a transfer from and a transfer to
- 25 entries
- Table 5

Table 6. Summary of transfer acres in the TBNRD

TBNRD			To		From	
Year	To	From	Current Year	Next Year	Current Year	Next Year
2010	74.4	75.7	48.7	25.7	50.0	25.7
2011	158.0	158.0	153.0	5.0	153.0	5.0
2012	188.4	194.1	113.3	75.1	113.3	80.8
2013	234.3	250.8	154.3	80.0	164.8	86.0

Table 7. Summary of transfer acres in the TBNRD adjusted for timing within the year.

Adjusted		
Year	To	From
2011	178.7	178.7
2012	118.3	118.3
2013	229.4	245.6

The sheet 'Variances' includes the TBNRD variances. These changes tended to be administrative rather than identifying acreage changes. It was decided in the August 2017 meeting that the robust review did not need to consider variances.

The sheet 'Corrections' contained 36 entries. These entries can be divided into two sets. The first set is administrative changes in the number of irrigated acres rather than changes to the acre location. No action was taken for these entries.

The second set is the CRP reinstated acres. The table only includes the reinstatement of the acres, it does not include when the land went into the program. CRP contracts typically enroll land for 10-15 years. For the Robust Review, it was assumed each contract was for 10 years.

CRP Acre Reinstatement

- Robust Review Assignment: Temporary Retirements
- Contract are for 10 years
- 4 entries
- Table 2 & Table 4

The sheet 'Conversion' contains 4 entries for the conversion of irrigation to watering livestock. Two of these entries occurred in the 2011-2013 timeframe. These transactions were treated as transfers.

Conversions

- Robust Review Assignment: Transfer away
- 2 entries
- Table 5

DNR provided the shape file *CREP* on 8/17/2017. It was supplemented by *20170829_COHYSTAreaMissingDates.xlsx* provide on 8/29/2017.

This shape file included the updated list of CREP and EQIP contracts. This file included CREP, EQIP, and TBEQIP parcels. The data in the CREP shape file was clipped to the TBNRD resulting in 114. The information was limited to contracts initiated prior to the end of 2013. Furthermore, the information was limited to the drainage area to the Platte River. Next the records were limited to contracts on groundwater only lands. Finally, the records were compared to the EQIP records from *TBNRD Appendix I_Conservation practices.sxlsx* sheet 'EQIP D land' and sheet 'CREP Acres'. The location timing of the 'EQIP D land' records did not overlap and records in CREP shape file. The entry from 'CREP Acres' matched a record in the CREP shapefile. The entry from the CREP shape file was used. This resulted in 21 parcels being applied to the robust review.

Table 8. DNR CREP and EQIP temporary retirements.

Year	CREP	EQIP	TBEQIP
2005	-	169.7	-
2006	1,029.8	-	-
2007	416.7	-	-
2008	16.6	-	380.1
2009	-	-	-
2010	2.6	-	-
Total	1,465.7	169.7	380.1

Table 9. DNR CREP and EQIP temporary retirements within the Platte River drainage Basin.

Year	CREP	TBEQIP	End Year
2005	-	-	
2006	30.0	-	2017
2007	-	-	
2008	-	157.4	2013
2009	-	-	
2010	-	-	
Total	30.0	167.9	

The CREP shape file was missing contract beginning and ending dates. DNR provided the contract dates in the supplementary file.

DNR CREP/EQIP
- Robust Review Assignment: Temporary Retirement
- 21 entries
- Table 2 & Table 4 & Table 9

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers and variances to the COHYST model grid. This was accomplished either by overlaying the parcels' shape file with the model grid. Or linking the parcels' legal description to model cells.

Step 1: Assigning land use change location

Each of the transactions provided by TBNRD included a legal description. These descriptions typically included the quarter section in which the transaction took place. This information needed to be linked to the COHYST 2010 model grid. COHYST uses a 160 acre grid; but, the cell boundaries and the section lines do not overlap. To accommodate this, the section shape file was spatially joined with the cell centroid. Typically, this would result in 4 cells being assigned to a section. Using the quarter section identifier, the cell which best represented the spatial location of the transaction was assigned the placement.[1]

Table 10. Approach used to link legal descriptions to model cell locations.

Cell Index	Row	Column	Quarter
Cell	x	y	NW
Cell + 1	x	y + 1	NE
Cell + 504	x + 1	y	SW
Cell + 505	x + 1	y + 1	SE

[1] For irregular sections, the cell-section relationship and professional judgement was used to place the transaction acres as close as possible to the defined location.

DNR provided a shape file for their retirements. The union function within ArcGIS was applied to the CREP shapefile and the model grid to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS.

Step 2: Building the Baseline Land Use Update

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update is the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all the temporarily retire acres.[2]

Acres were to be added or removed from their assigned cells. If there was insufficient space[3] for new acres or an insufficient amount of groundwater only acres[4] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[5]. This spatial process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom piece of FORTRAN script.

[2] 2023 was identified as the year the last TPNRD temporary retirement would be actively irrigated again for the first time

[3] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres

[4] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres

[5] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres.

The results of Step 2 are shown in Table 11, which match the results summarized in Table 1 for the years 2011-2017. The exception being 2013. The location of two transactions placed them in cells designated CPNRD. This accounted for 77.1 acres from the transfer away data set being in CPNRD (58.6 in Dawson County, 18.5 in Buffalo County).

It should be noted again that the cell boundaries do not necessarily overlap with the legal boundaries, either county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 11. Change in groundwater only irrigated acres within the TBNRD for the Robust Review baseline.

Year	Groundwater Only Irrigated Acres	Annual Change in Groundwater Only Irrigated Acres in TBNRD vs 2010	Change in Groundwater Only Irrigated Acres not in TBNRD
2010	459,902.8	-	
2011	460,343.0	440.2	
2012	460,756.3	413.3	
2013	461,269.2	512.9	(77.1)
2014	461,396.5	127.3	
2015	461,524.4	127.9	
2016	461,524.4	-	
2017	461,563.4	39.0	

Step 3: Building the Unretired Acres Scenario Modified Land Use

Similarly, a new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired.

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retire acres added back in 2011 and remain moving forward.

Tables 12-13 show that given a summary of the modified land use files, one can trace back changes to the summary of transactions applied to create the files.

Table 12 shows the changes between the COHYST 2010 land use and the unretired retirements scenario. The difference between the two data sets shows the cumulative change over time. However, looking at the change in the cumulative total one arrives at the retired acres shown in Table 1.

Table 12. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres	
Year	COHYST 2010	Modified Land Use	Cumulative	Annual
1999	408,126	408,128.2	1.9	1.9
2000	409,469	409,764.4	295.5	293.6
2001	409,418	410,122.3	704.1	408.6
2002	421,829	422,533.2	704.1	0.0
2003	422,302	423,006.6	704.2	0.1
2004	423,360	424,134.9	774.8	70.6
2005	422,424	423,457.7	1,033.9	259.1
2006	439,644	440,841.7	1,197.9	164.0
2007	464,704	466,122.4	1,418.0	220.1
2008	444,988	447,099.2	2,111.4	693.4
2009	471,247	473,281.1	2,034.0	(77.4)
2010	459,903	461,643.7	1,740.9	(293.1)
		Cumulative		1,740.9

Table 13 show the changes between the COHYST 2010 2010 land use file and the unretired retirement scenario land use for the robust review. The table shows you the annual modified land use's groundwater only irrigated lands. The next column shows the modified land use's groundwater only irrigated lands minus the COHYST 2010's 2010 land use and the cumulative effect of unretiring acres. For the values in this column on must consider: the retired acres to be unretired prior to 2011, retired acres which were reinstated prior to 2011, and finally the cumulative retirements and net transfers away after 2010 but prior to the relevant year. The value in the third column is the also the retirements plus the transfers away minus the transfers to and minus those transfers away which were not in the summary area. By taking the transfers from Table 1 and the bit of information from Table 11 about the transfer away acres falling outside the TPNRD summary area we can get back to the post 2010 retirements shown in Table 1.

Table 13. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2017.

Year	Groundwater Only Irrigated Acres	Difference in Groundwater only Acres from 2010 minus cumulative prior retirements	Transfers Away	Transfers to	Non TBNRD Transfers Away	Net Transfers Away	Cumulative Net Transfers Away	Retirements
2011	461,687.1	43.4	246.7	178.7	-	67.9	67.9	111.3
2012	461,687.0	(0.1)	118.3	118.3	-	-	67.9	(0.1)
2013	461,747.8	60.8	245.6	229.4	77.1	(60.9)	7.1	(0.1)
2014	461,747.8	(7.1)	-	-	-	-	7.1	-
2015	461,747.8	(7.1)	-	-	-	-	7.1	-
2016	461,747.8	(7.1)	-	-	-	-	7.1	-
2017	461,747.8	(7.1)	-	-	-	-	7.1	-

Finally, Tables 14-15 show the annual area of groundwater only irrigated land for each county in the TBNRD.

Table 14. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892

Table 15. TBNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892

Table 14. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,325	165,623
2000	64,020	179,822	165,627
2001	64,705	179,524	165,188
2002	65,456	187,438	168,936
2003	66,229	187,575	168,498
2004	67,007	187,705	168,648
2005	67,899	187,429	167,096
2006	70,272	196,922	172,450
2007	85,141	200,533	179,031
2008	74,647	198,594	171,748
2009	91,432	200,132	179,683
2010	83,058	197,888	178,957
2011	83,049	198,307	178,987
2012	83,156	198,370	179,231
2013	83,198	198,502	179,570
2014	83,272	198,502	179,623
2015	83,272	198,518	179,734
2016	83,272	198,518	179,734
2017	83,272	198,518	179,773
2018	83,272	198,518	179,773
2019	83,272	198,518	179,773
2020	83,272	198,518	179,773
2021	83,272	198,518	179,773
2022	83,272	198,518	179,773

Table 15. TBNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Gosper	Kearney	Phelps
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,327	165,623
2000	64,020	180,099	165,646
2001	64,705	180,210	165,207
2002	65,456	188,123	168,955
2003	66,229	188,261	168,517
2004	67,007	188,468	168,660
2005	67,906	188,232	167,320
2006	70,330	197,742	172,769
2007	85,216	201,384	179,523
2008	74,828	199,550	172,721
2009	91,654	201,080	180,547
2010	83,304	198,543	179,797
2011	83,278	198,523	179,886
2012	83,278	198,523	179,886
2013	83,272	198,592	179,884
2014	83,272	198,592	179,884
2015	83,272	198,592	179,884
2016	83,272	198,592	179,884
2017	83,272	198,592	179,884
2018	83,272	198,592	179,884
2019	83,272	198,592	179,884
2020	83,272	198,592	179,884
2021	83,272	198,592	179,884
2022	83,272	198,592	179,884

Table 14. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2023	83,272	198,518	179,773
2024	83,272	198,518	179,773
2025	83,272	198,518	179,773
2026	83,272	198,518	179,773
2027	83,272	198,518	179,773
2028	83,272	198,518	179,773
2029	83,272	198,518	179,773
2030	83,272	198,518	179,773
2031	83,272	198,518	179,773
2032	83,272	198,518	179,773
2033	83,272	198,518	179,773
2034	83,272	198,518	179,773
2035	83,272	198,518	179,773
2036	83,272	198,518	179,773
2037	83,272	198,518	179,773
2038	83,272	198,518	179,773
2039	83,272	198,518	179,773
2040	83,272	198,518	179,773
2041	83,272	198,518	179,773
2042	83,272	198,518	179,773
2043	83,272	198,518	179,773
2044	83,272	198,518	179,773
2045	83,272	198,518	179,773
2046	83,272	198,518	179,773
2047	83,272	198,518	179,773
2048	83,272	198,518	179,773
2049	83,272	198,518	179,773
2050	83,272	198,518	179,773
2051	83,272	198,518	179,773
2052	83,272	198,518	179,773
2053	83,272	198,518	179,773
2054	83,272	198,518	179,773
2055	83,272	198,518	179,773
2056	83,272	198,518	179,773
2057	83,272	198,518	179,773
2058	83,272	198,518	179,773
2059	83,272	198,518	179,773
2060	83,272	198,518	179,773

Table 15. TBNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Gosper	Kearney	Phelps
2023	83,272	198,592	179,884
2024	83,272	198,592	179,884
2025	83,272	198,592	179,884
2026	83,272	198,592	179,884
2027	83,272	198,592	179,884
2028	83,272	198,592	179,884
2029	83,272	198,592	179,884
2030	83,272	198,592	179,884
2031	83,272	198,592	179,884
2032	83,272	198,592	179,884
2033	83,272	198,592	179,884
2034	83,272	198,592	179,884
2035	83,272	198,592	179,884
2036	83,272	198,592	179,884
2037	83,272	198,592	179,884
2038	83,272	198,592	179,884
2039	83,272	198,592	179,884
2040	83,272	198,592	179,884
2041	83,272	198,592	179,884
2042	83,272	198,592	179,884
2043	83,272	198,592	179,884
2044	83,272	198,592	179,884
2045	83,272	198,592	179,884
2046	83,272	198,592	179,884
2047	83,272	198,592	179,884
2048	83,272	198,592	179,884
2049	83,272	198,592	179,884
2050	83,272	198,592	179,884
2051	83,272	198,592	179,884
2052	83,272	198,592	179,884
2053	83,272	198,592	179,884
2054	83,272	198,592	179,884
2055	83,272	198,592	179,884
2056	83,272	198,592	179,884
2057	83,272	198,592	179,884
2058	83,272	198,592	179,884
2059	83,272	198,592	179,884
2060	83,272	198,592	179,884

Table 14. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2061	83,272	198,518	179,773
2062	83,272	198,518	179,773
2063	83,272	198,518	179,773

Table 15. TBNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Gosper	Kearney	Phelps
2061	83,272	198,592	179,884
2062	83,272	198,592	179,884
2063	83,272	198,592	179,884

Memorandum

To: Ann Dimmit – TPNRD; Kari Burgert – DNR
From: The Flatwater Group, Inc.
Date: 7/13/2018
Subject: COHYST Area Robust Review: TPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Nebraska Department of Natural Resources (DNR) on the COHYST area Robust Review project. The Robust Review project's purpose is to evaluate the impacts of land use changes to streamflow. To account for transfers, retirements, and variances within the Twin Platte Natural Resources District (TPNRD), TFG's primary work tasks include evaluating and summarizing the transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013 and create a new land use data set for the unretired scenario.

For the first step in the process, TFG worked with DNR and TPNRD to gather the land use data (retirements, transfers, and variances) into summary tables by land use type. TFG's next step was to perform a geospatial analysis to identify the location of each transaction. The geospatial analysis included a proximity function to determine the closest available model cells capable of accommodating land use changes. ArcGIS and custom script were used for the analysis and the results were organized into Tables 4-8.

This memo presents summary tables of retirement acres and transfer acres within the TPNRD, outlines the spatial analysis methodology, and then summarizes the resultant land use files. Spatial analysis was provided in shapefile format and spatially analyzed using ArcGIS and custom FORTRAN programs.

Land Use Summary Tables

TFG has compiled a final summary of the retirements, transfers, and variances for the TPNRD from the information provided by TPNRD and the DNR. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these action as part of the larger Robust Review effort. Table 1 shows an overview summary of retirements and transfers in the TPNRD. Tables 2-3 show summaries of the individual categories used to create Table 1 and serve as a reference fro the description of each data source.

Table 1. Summary of TPNRD acres changes for implementation into the Robust Review.

Year	Temporary Retirements	Reinstated Temporary Retirements	Transfers To	Transfers Away	Change
Baseline Change	(-)	(+)	(+)	(-)	
2006	595.6	-	-	-	(595.64)
2007	27.4	-	-	-	(27.40)
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	833.0	815.7	17.27
2012	40.8	28.8	1,569.3	1,635.4	(78.10)
2013	-	-	1,865.7	1,840.6	25.10
2014	-	-	-	-	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	-	594.2	-	-	594.24
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	-	-	-	-	-
2023	-	40.8	-	-	40.80
Total	663.8	663.8	4,268.0	4,291.7	(23.7)

The TPNRD provided updated changes land change files on 8/8/2017 in the form of shape files:

TPNRD_Acres_Decertified_Implemented_through_2013

TPNRD_New_Acres_implemented_through_2013

These two files contain the spatial location and area of the transfers within the TPNRD.

Decertified Acres

- 229 entries
- 149 occurred between 2011 and 2013
- Timing was based upon the implementation year
- In 2013, 234.3 acres of provided decertified acres were located outside the COHYST 2010 active model domain. They were not considered when modifying the land use.
- Table 2

New Acres

- 187 entries
- 131 occurred between 2011 and 2013
- Timing was based upon the implementation year
- Table 2

Table 2. Summary of transfer acres in the TPNRD

	TPNRD Updated			
Year	New Acres	Decertified Acres	Decertified Acres in Non-Active Cells	Modeled Decertified Acres
2011	833.0	815.7	-	815.7
2012	1,569.3	1,635.4	-	1,635.4
2013	1,865.7	2,074.9	234.3	1,840.6
Total	4,268.0	4,526.0	234.3	4,291.7

DNR provided the *CREP* shape file on 8/17/2017

This shape file included the updated list of CREP and EQIP contracts. The data was clipped to the TPNRD resulting in 59 polygons totaling 1641 acres. The information was limited to groundwater only irrigated (Irrigation = 1), trimming the area to 14 polygons and 905 acres. Finally, the polygons were reduced to those which were initiated prior to the 2013 irrigation season. This left the data set with 11 entries with 664 acres. Each of these 11 entries were CREP contracts. Contracts lengths were either 5, 10, or 11 years (Table 3).

To be considered for the current year, the retirement needed to be initiated or ended prior to July of the current year; otherwise, the transaction will have its first effect in the next year. The rationale is that if the action was taken prior to July, the transaction could influence the irrigation season in the current year. However, if the transaction occurred later, the land would finish up the current growing season in the same state.

Table 3. Summary of temporary retirements and reinstated retirement acres in the TPNRD

Year	Temporary Retirements
2006	595.6
2007	27.4
2008	-
2009	-
2010	-
2011	-
2012	40.8
2013	-
2014	-
2015	-
2016	-
2017	-
2018	-
2019	-
2020	-
2021	-
2022	-
2023	-
Total	663.8

Year	Reinstated Retirements
2006	-
2007	-
2008	-
2009	-
2010	-
2011	-
2012	28.8
2013	-
2014	-
2015	-
2016	-
2017	594.2
2018	-
2019	-
2020	-
2021	-
2022	-
2023	40.8
Total	663.8

All transactions in the TPNRD were provide in shape files. These polygons were overlaid on the COHYST 2010 model grid with the union function in ArcGIS. This returned the number of acres in each cell for each transaction.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers, and variances to the COHYST model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

DNR and TPNRD provided shape files for their retirements and transfers. The union function within ArcGIS was applied to the shapefiles to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS.

Step 2: Building the Baseline Land Use

The next step is to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update is the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of the investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all the temporarily retired acres. [1]

Acres were to be added or removed from their assigned cells. If there was insufficient space[2] for new acres or an insufficient amount of groundwater only acres[3] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[4]. This spatial process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom piece of FORTRAN script.

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. 'r' and 'c' indicate the row column index of the cell.

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[1] 2023 was identified as the year the last TPNRD temporary retirement would be actively irrigated again for the first time

[2] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres

[3] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres

[4] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

The results of Step 2 are shown in Table 4 which match the results summarized in Table 1 for the years 2011-2023. The exceptions being in 2011 and 2012. In 2011, the location of a couple of transaction were placed in cells designated CPNRD or URNRD; 11.4 new acres were placed in the URNRD in Perkins County, while 1.6 acres were removed from CPNRD in Dawson County. Likewise, in 2012, 3.8 acres were removed from CPNRD in Dawson County. These placements were from the New Acres and Decertified Acres data sets.

It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 4. Change in groundwater only irrigated acres within the TPNRD for the Robust Review baseline.

Year	Groundwater Only Irrigated Acres	Annual Change in Groundwater Only Irrigated Acres in TPNRD vs 2010	Change in Groundwater Only Irrigated Acres not in TPNRD
2010	263,165.7	-	-
2011	263,173.8	8.1	9.8
2012	263,099.6	(74.2)	(3.8)
2013	263,124.4	24.8	-
2014	263,124.4	-	-
2015	263,124.4	-	-
2016	263,124.4	-	-
2017	263,718.3	593.9	-
2018	263,718.3	-	-
2019	263,718.3	-	-
2020	263,718.3	-	-
2021	263,718.3	-	-
2022	263,718.3	-	-
2023	263,759.1	40.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

A new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired.

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retire acres added back in 2011 and remain moving forward.

Tables 5-6 show that given a summary of the modified land use files, one can trace back change to the summary of transactions applied to create these files.

Table 5 shows the changes between the COHYST 2010 land use and the unretired retirements scenario. The difference between the two data sets shows the cumulative change over time. However, looking at the change in the cumulative total one arrives at the retired acres shown in Table 1.

Table 5. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres	
Year	Run029	Modified Land Use	Cumulative	Annual
1999	208,718	208,718.0	-	-
2000	210,934	210,933.7	-	-
2001	213,311	213,311.4	-	-
2002	221,892	221,892.1	-	-
2003	233,442	233,442.3	-	-
2004	245,508	245,507.7	-	-
2005	250,480	250,479.6	-	-
2006	258,475	259,070.3	595.4	595.4
2007	267,919	268,541.2	622.6	27.2
2008	265,482	266,104.8	622.7	0.1
2009	267,862	268,485.1	622.7	-
2010	263,166	263,788.4	622.7	0.0
		Cumulative		622.7

Table 6 show the changes between the COHYST 2010's 2010 land use file and the unretired retirement scenario land use for the robust review. The table shows you the annual modified land use's groundwater only irrigated lands. The next column shows the modified land use's groundwater only irrigated lands minus the COHYST 2010's 2010 land use and the cumulative effect of unretiring acres. For the values in this column one must consider: the retired acres to be unretired prior to 2011, retired acres which were reinstated prior to 2011, and finally the cumulative retirements and net transfers away after 2010 but prior to the relevant year. The value in the third column is the also the retirements plus the transfers away minus the transfers to and minus those transfers away which were not in the summary area. By taking the transfers from Table 2 and the transfer acres falling outside the TPNRD from Table 4 about the transfer acres falling outside the TPNRD summary area we can get back to the post 2010 retirements shown in Table 1.

Table 6. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2017.

Year	Groundwater Only Irrigated Acres	Difference in Groundwater only Acres from 2010 minus cumulative prior retirements	Transfers Away	Transfers to	Non TPNRD Transfers Away	Net Transfers Away	Cumulative Net Transfers Away	Retirements
2011	263,796.5	8.1	815.7	833.0	(9.8)	(7.5)	(7.5)	0.6
2012	263,775.2	(21.3)	1,635.4	1,569.3	3.8	62.3	54.8	41.0
2013	263,800.0	24.8	1,840.6	1,865.7	-	(25.1)	29.7	(0.3)
2014	263,800.0	-	-	-	-	-	29.7	-
2015	263,800.0	-	-	-	-	-	29.7	-
2016	263,800.0	-	-	-	-	-	29.7	-
2017	263,800.0	-	-	-	-	-	29.7	-
2018	263,800.0	-	-	-	-	-	29.7	-
2019	263,800.0	-	-	-	-	-	29.7	-
2020	263,800.0	-	-	-	-	-	29.7	-
2021	263,800.0	-	-	-	-	-	29.7	-
2022	263,800.0	-	-	-	-	-	29.7	-
2023	263,800.0	-	-	-	-	-	29.7	-

Finally, Tables 7-8 show the annual area of groundwater only irrigated land for each county in the TPNRD within the Robust Review's baseline and Unretirement Scenarios.

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
1950	-	3,940	2,329	-	-
1951	-	5,100	2,338	-	-
1952	-	6,508	2,496	-	-
1953	-	7,848	3,049	-	-
1954	-	8,869	4,411	-	140
1955	259	9,516	6,515	-	140
1956	235	9,873	8,285	-	140
1957	280	10,202	10,006	-	140
1958	237	10,809	11,681	-	140
1959	259	11,064	13,596	-	140
1960	280	12,154	13,940	-	140
1961	358	12,975	13,933	-	280
1962	365	14,036	14,258	-	280
1963	336	15,026	14,721	-	420
1964	330	15,865	14,864	-	420
1965	420	18,019	17,328	-	420
1966	399	19,825	19,369	-	420
1967	549	22,606	21,894	-	420
1968	906	24,595	23,982	-	700
1969	1,159	26,818	26,102	-	840
1970	1,400	28,644	31,203	-	980
1971	1,839	30,082	35,802	-	980
1972	1,818	31,813	40,612	-	980
1973	1,933	33,438	45,704	-	1,260

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
1950	-	3,940	2,329	-	-
1951	-	5,100	2,338	-	-
1952	-	6,508	2,496	-	-
1953	-	7,848	3,049	-	-
1954	-	8,869	4,411	-	140
1955	259	9,516	6,515	-	140
1956	235	9,873	8,285	-	140
1957	280	10,202	10,006	-	140
1958	237	10,809	11,681	-	140
1959	259	11,064	13,596	-	140
1960	280	12,154	13,940	-	140
1961	358	12,975	13,933	-	280
1962	365	14,036	14,258	-	280
1963	336	15,026	14,721	-	420
1964	330	15,865	14,864	-	420
1965	420	18,019	17,328	-	420
1966	399	19,825	19,369	-	420
1967	549	22,606	21,894	-	420
1968	906	24,595	23,982	-	700
1969	1,159	26,818	26,102	-	840
1970	1,400	28,644	31,203	-	980
1971	1,839	30,082	35,802	-	980
1972	1,818	31,813	40,612	-	980
1973	1,933	33,438	45,704	-	1,260

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
1974	2,203	35,177	50,349	-	1,540
1975	2,881	40,123	57,650	-	1,540
1976	3,068	46,074	62,725	-	1,540
1977	3,912	52,163	69,618	-	1,820
1978	5,277	57,650	76,349	-	2,940
1979	5,602	59,990	78,875	-	3,560
1980	6,470	62,452	82,621	-	4,158
1981	7,300	65,245	85,496	-	4,387
1982	7,653	67,611	88,954	-	4,746
1983	7,551	67,158	88,061	-	4,972
1984	7,670	67,173	85,653	-	5,350
1985	10,496	59,997	98,168	-	4,987
1986	10,513	60,079	97,769	-	5,094
1987	10,691	59,892	96,995	-	5,263
1988	10,714	61,442	97,483	-	5,323
1989	10,824	63,871	98,705	-	5,380
1990	10,845	65,847	99,915	-	5,438
1991	10,868	67,211	100,718	-	5,494
1992	10,906	68,534	102,556	-	5,573
1993	10,929	69,355	103,469	-	5,561
1994	11,067	71,249	104,183	-	5,550
1995	11,209	72,978	105,622	-	5,545
1996	11,461	75,348	108,418	-	5,541
1997	11,506	78,805	109,820	-	5,541
1998	11,206	79,530	111,194	70	5,226
1999	10,793	80,715	112,136	87	4,987
2000	10,471	82,230	113,302	104	4,826

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
1974	2,203	35,177	50,349	-	1,540
1975	2,881	40,123	57,650	-	1,540
1976	3,068	46,074	62,725	-	1,540
1977	3,912	52,163	69,618	-	1,820
1978	5,277	57,650	76,349	-	2,940
1979	5,602	59,990	78,875	-	3,560
1980	6,470	62,452	82,621	-	4,158
1981	7,300	65,245	85,496	-	4,387
1982	7,653	67,611	88,954	-	4,746
1983	7,551	67,158	88,061	-	4,972
1984	7,670	67,173	85,653	-	5,350
1985	10,496	59,997	98,168	-	4,987
1986	10,513	60,079	97,769	-	5,094
1987	10,691	59,892	96,995	-	5,263
1988	10,714	61,442	97,483	-	5,323
1989	10,824	63,871	98,705	-	5,380
1990	10,845	65,847	99,915	-	5,438
1991	10,868	67,211	100,718	-	5,494
1992	10,906	68,534	102,556	-	5,573
1993	10,929	69,355	103,469	-	5,561
1994	11,067	71,249	104,183	-	5,550
1995	11,209	72,978	105,622	-	5,545
1996	11,461	75,348	108,418	-	5,541
1997	11,506	78,805	109,820	-	5,541
1998	11,206	79,530	111,194	70	5,226
1999	10,793	80,715	112,136	87	4,987
2000	10,471	82,230	113,302	104	4,826

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2001	9,487	84,154	115,231	122	4,318
2002	9,272	86,334	121,088	122	5,077
2003	9,507	89,925	128,681	122	5,207
2004	9,732	94,959	135,355	122	5,339
2005	10,096	95,166	139,304	123	5,791
2006	10,232	95,184	147,506	126	5,427
2007	11,112	98,022	152,349	126	6,310
2008	10,687	97,668	150,662	126	6,339
2009	10,113	98,320	152,749	126	6,554
2010	9,180	97,947	150,323	132	5,583
2011	9,180	97,885	150,394	132	5,583
2012	9,180	97,901	150,304	132	5,583
2013	8,613	97,725	151,061	132	5,593
2014	8,613	97,725	151,061	132	5,593
2015	8,613	97,725	151,061	132	5,593
2016	8,613	97,725	151,061	132	5,593
2017	8,613	98,291	151,088	132	5,593
2018	8,613	98,291	151,088	132	5,593
2019	8,613	98,291	151,088	132	5,593
2020	8,613	98,291	151,088	132	5,593
2021	8,613	98,291	151,088	132	5,593
2022	8,613	98,291	151,088	132	5,593
2023	8,613	98,291	151,129	132	5,593
2024	8,613	98,291	151,129	132	5,593
2025	8,613	98,291	151,129	132	5,593
2026	8,613	98,291	151,129	132	5,593
2027	8,613	98,291	151,129	132	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2001	9,487	84,154	115,231	122	4,318
2002	9,272	86,334	121,088	122	5,077
2003	9,507	89,925	128,681	122	5,207
2004	9,732	94,959	135,355	122	5,339
2005	10,096	95,166	139,304	123	5,791
2006	10,232	95,779	147,506	126	5,427
2007	11,112	98,617	152,376	126	6,310
2008	10,687	98,263	150,690	126	6,339
2009	10,113	98,915	152,776	126	6,554
2010	9,180	98,543	150,351	132	5,583
2011	9,180	98,480	150,421	132	5,583
2012	9,180	98,467	150,413	132	5,583
2013	8,613	98,291	151,170	132	5,593
2014	8,613	98,291	151,170	132	5,593
2015	8,613	98,291	151,170	132	5,593
2016	8,613	98,291	151,170	132	5,593
2017	8,613	98,291	151,170	132	5,593
2018	8,613	98,291	151,170	132	5,593
2019	8,613	98,291	151,170	132	5,593
2020	8,613	98,291	151,170	132	5,593
2021	8,613	98,291	151,170	132	5,593
2022	8,613	98,291	151,170	132	5,593
2023	8,613	98,291	151,170	132	5,593
2024	8,613	98,291	151,170	132	5,593
2025	8,613	98,291	151,170	132	5,593
2026	8,613	98,291	151,170	132	5,593
2027	8,613	98,291	151,170	132	5,593

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2028	8,613	98,291	151,129	132	5,593
2029	8,613	98,291	151,129	132	5,593
2030	8,613	98,291	151,129	132	5,593
2031	8,613	98,291	151,129	132	5,593
2032	8,613	98,291	151,129	132	5,593
2033	8,613	98,291	151,129	132	5,593
2034	8,613	98,291	151,129	132	5,593
2035	8,613	98,291	151,129	132	5,593
2036	8,613	98,291	151,129	132	5,593
2037	8,613	98,291	151,129	132	5,593
2038	8,613	98,291	151,129	132	5,593
2039	8,613	98,291	151,129	132	5,593
2040	8,613	98,291	151,129	132	5,593
2041	8,613	98,291	151,129	132	5,593
2042	8,613	98,291	151,129	132	5,593
2043	8,613	98,291	151,129	132	5,593
2044	8,613	98,291	151,129	132	5,593
2045	8,613	98,291	151,129	132	5,593
2046	8,613	98,291	151,129	132	5,593
2047	8,613	98,291	151,129	132	5,593
2048	8,613	98,291	151,129	132	5,593
2049	8,613	98,291	151,129	132	5,593
2050	8,613	98,291	151,129	132	5,593
2051	8,613	98,291	151,129	132	5,593
2052	8,613	98,291	151,129	132	5,593
2053	8,613	98,291	151,129	132	5,593
2054	8,613	98,291	151,129	132	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2028	8,613	98,291	151,170	132	5,593
2029	8,613	98,291	151,170	132	5,593
2030	8,613	98,291	151,170	132	5,593
2031	8,613	98,291	151,170	132	5,593
2032	8,613	98,291	151,170	132	5,593
2033	8,613	98,291	151,170	132	5,593
2034	8,613	98,291	151,170	132	5,593
2035	8,613	98,291	151,170	132	5,593
2036	8,613	98,291	151,170	132	5,593
2037	8,613	98,291	151,170	132	5,593
2038	8,613	98,291	151,170	132	5,593
2039	8,613	98,291	151,170	132	5,593
2040	8,613	98,291	151,170	132	5,593
2041	8,613	98,291	151,170	132	5,593
2042	8,613	98,291	151,170	132	5,593
2043	8,613	98,291	151,170	132	5,593
2044	8,613	98,291	151,170	132	5,593
2045	8,613	98,291	151,170	132	5,593
2046	8,613	98,291	151,170	132	5,593
2047	8,613	98,291	151,170	132	5,593
2048	8,613	98,291	151,170	132	5,593
2049	8,613	98,291	151,170	132	5,593
2050	8,613	98,291	151,170	132	5,593
2051	8,613	98,291	151,170	132	5,593
2052	8,613	98,291	151,170	132	5,593
2053	8,613	98,291	151,170	132	5,593
2054	8,613	98,291	151,170	132	5,593

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2055	8,613	98,291	151,129	132	5,593
2056	8,613	98,291	151,129	132	5,593
2057	8,613	98,291	151,129	132	5,593
2058	8,613	98,291	151,129	132	5,593
2059	8,613	98,291	151,129	132	5,593
2060	8,613	98,291	151,129	132	5,593
2061	8,613	98,291	151,129	132	5,593
2062	8,613	98,291	151,129	132	5,593
2063	8,613	98,291	151,129	132	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2055	8,613	98,291	151,170	132	5,593
2056	8,613	98,291	151,170	132	5,593
2057	8,613	98,291	151,170	132	5,593
2058	8,613	98,291	151,170	132	5,593
2059	8,613	98,291	151,170	132	5,593
2060	8,613	98,291	151,170	132	5,593
2061	8,613	98,291	151,170	132	5,593
2062	8,613	98,291	151,170	132	5,593
2063	8,613	98,291	151,170	132	5,593

Memorandum

To: Brandi Flyr – Central Platte NRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 10/17/2018
Subject: COHYST Area Robust Review: CPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Central Platte NRD (CPNRD).

To evaluate changes to land use within the CPNRD, TFG's primary work tasks included compiling available acreage change information; spatially processing the compiled information to ensure unique datasets; developing land use summary tables to facilitate review of the provided information; placing the acreage change transactions into the constructs of the COHYST 2010 watershed model's land use files in order to extend the baseline land use dataset through 2013; and finally to then create a new land use data set for the Robust Review's unretired scenario.

Data Collection and Spatial Processing

For the first step in the process, TFG worked with NDNR and CPNRD to gather available land use change information. Ultimately, CPNRD provided four ArcGIS® shape files and NDNR provide one ArcGIS® shape file and an Excel spreadsheet upon which the analyses for CPNRD were based. The shape files from CPNRD were named:

- *Acres_Added_2_13_2018.shp*
  - Contains spatial locations of areas where irrigation was transferred to
  - Comprised of 2,925 entries
  - 970 of those entries occurred between 2011 and 2013
- *Acres_Offset_2_13_2018.shp*
  - Contains spatial location of areas where irrigation was transferred from
  - Comprised of 3,287 entries
  - 725 of those entries occurred between 2011 and 2013
- *CPNRD_2004_CIA_2018_02_13.shp*
  - 2004 certified acreage coverage
- *WB_PURCHASES.shp*
  - Spatial location of permanent retirements initiated through CPNRD's water bank.
  - Contained 71 entries

NDNR provided the following files:

- *CREP.shp*
  - Contains spatial locations of retirements funded with either CREP or EQIP funds and tracked by NDNR

- *20180829_COHYSTAreaMissing Dates.xlsx*
  - Provided supplementary contract starting and end dates for parcels included in *CREP.shp*.

To ensure that the spatial information provided was unique and did not reflect overlapping polygons, the information was linked to the COHYST 2010 model grid. COHYST 2010 uses a grid of 160-acre sized model cells. Cells are assigned to counties, NRDs, and/or drainage basins based on the location of the cell's centroid. This results in a model cell being assigned a single value for a given feature class. For example, if the border of an NRD passes through a model cell, whichever NRD the cell's centroid is within determines which NRD the cell is assigned to within the model. For this reason, it is possible to have an activity which occurs within a cell along a feature border to be enacted by one entity that shares the border, but for the model to summarize the activity to the other entity which shares the border.

After joining the provided spatial information to the COHYST 2010 model grid, the following observations were made:

1. There were multiple overlapping parcels within the *Acres_Added_2_13_2018.shp* and *Acres_Offset_2_13_2018.shp* datasets
   a. This led to potential changes in ground water only irrigated lands greater than the number of acres within a cell
2. There were irrigated acres to be offset that did not have an underlying entry in the *CPNRD_2004_CIA_2018_02_13.shp* dataset.
3. The majority of the parcels identified in *WB_PURCHASES.shp* were also included in the *Acres_Offset_2_13_2018.shp dataset*
   a. There was one completely unique WB entry
4. The *WB_PURCHASES.shp* dataset included transactions for surface water and comingled acres as well as ground water only acres

With respect to item 1 above, to account for the overlapping parcels within the acreage transfer datasets, the shape files were dissolved by the transfer year using the software ArcGIS®. This eliminated the ability to add or remove the same acres multiple time in a single year but allowed for transfers to and from in subsequent years. The 'Union' function within ArcGIS® was used to associate the transfer and retirement shape file information to the COHYST model grid.

After discussion with CPNRD regarding item 2, the offset acreage parcels which did not have an underlying entry in the certified acreage dataset were identified and returned to CPNRD. CPNRD determined if the parcels were truly offset acres; ultimately providing TFG with their recommendations on which parcels to omit from the analysis. TFG removed these parcels from the dataset moving forward.

After additional discussions with CPNRD about item 3, it was determined that the *Acres_Offset_2_13_2018.shp* dataset included both transfers away <u>and</u> permanent retirements (which were initially believed to be contained in the *WB_PURCHASES.shp* dataset). The *WB_PURCHASES.shp* coverage was spatially queried against the *Acres_Offset_2_13_2018.shp* dataset to determine which offset transactions were retirements. The *Acres_Offset_2_13_2018.shp* dataset was then divided into two sets: offset transfers and offset retirements.

Item 4 was noted due to the Robust Review being focused on ground water only transactions. The offset acreage transactions which had a designation of surface water only or comingled were therefore removed.

Land Use Summary Tables

Using information provided by CPNRD, NDNR, and other basin NRDs, TFG compiled a final summary of the retirements, transfers, and variances occurring within the CPNRD assigned model domain. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-7 below summarize the information provided to TFG. Tables 8-14 summarize the distribution of that information into the modeling input files.

Table 1 provides an overall summary of the retirement and transfer acreage source information relevant to the CPNRD received by TFG. Columns A through E on Table 1 summarize the information provided by CPNRD and NDNR. Column F summarizes information tracked by other basin NRDs, but whose spatial location upon distribution to the model placed acreage within the model domain assigned to the CPNRD. Subsequent tables define the source(s) of this information.

Table 1. Summary of CPNRD acreage changes for implementation into the Robust Review.

	CPNRD Data					Non-CPNRD Data	
Year	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Transfers Away	(G) Change
Baseline Change	(-)	(+)	(-)	(+)	(-)	(-)	
1999	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-
2005	304.4	-	-	-	-	-	(304.4)
2006	260.7	-	150.1	-	-	-	(410.8)
2007	111.9	-	-	-	-	-	(111.9)
2008	52.2	-	-	-	-	-	(52.2)
2009	6.9	-	1,513.8	-	-	-	(1,520.7)
2010	-	-	317.8	-	-	-	(317.8)
2011	-	-	430.8	1,087.2	683.5	1.6	(28.7)
2012	-	-	211.3	4,397.8	1,021.6	3.8	3,161.1
2013	-	-	19.1	4,255.3	1,440.0	77.1	2,719.1
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	282.7	-	-	-	-	282.7
2019	-	21.5	-	-	-	-	21.5
2020	-	39.7	-	-	-	-	39.7
2021	-	196.4	-	-	-	-	196.4
2022	-	125.0	-	-	-	-	125.0
2023	-	70.8	-	-	-	-	70.8
Total	736.1	736.1	2,642.9	9,740.3	3,145.1	82.5	3,869.8

Data Source Discussion for Table 1 Columns A-B

The CREP related information provided by NDNR was the source of the temporary retirement information summarized in Column A of Table 1. The *CREP.shp* file included the most up to date list of CREP and EQIP contracts available from NDNR. TFG queried the data spatially in the shape file to obtain only the parcels located within the CPNRD. That query returned 58 polygons totaling 1,640 acres. The information was then limited to parcels irrigated only with ground water and which were initiated prior to the 2013 irrigation season. This reduced the number of acres to 876.4.

A spatial comparison of the CREP/EQIP information provided by NDNR and the permanent retirement information provided by CPNRD (via *WB_PURCHASES.shp*) revealed a small amount of overlap between the two datasets. The overlapping acres were removed from the *CREP.shp* dataset and retained in the in the CPNRD provided information; however, the date the retirements were initiated was changed to reflect the initial temporary retirement year (from 2009 to 2006). This resulted in 140.3 acres being converted from temporarily retired to permanently retired. Reducing the remaining 876.4 CREP/EQIP retirement acres by the 140.3 acres yields 736.1 acres within the CPNRD area (and an additional 0.7 acres in the TBNRD area due to the cell assignment procedures discussed earlier). Table 2 summarizes these values. Note that Column 'CPNRD' on Table 2 is the source of the information populated into Column A of Table 1.

Table 2. Summary of CPNRD CREP and EQIP temporary retirements.

Year	Total	CPNRD	TBNRD
2005	304.4	304.4	-
2006	260.7	260.7	-
2007	111.9	111.9	-
2008	52.2	52.2	-
2009	7.6	6.9	0.7
2010	-	-	-
2011	-	-	-
2012	-	-	-
2013	-	-	-
Total	736.8	736.1	0.7

Based on the contract start and end dates contained in *CREP.shp* and *20180829_COHYSTAreaMissing Dates.xlsx*, the year the temporary retirements end was computed. This information is shown on Table 3. Note that Column 'CPNRD' on Table 3 is the source of the information populated into Column B of Table 1.

Table 3. Summary of CPNRD CREP and EQIP temporary retirements reinstatements.

Year	Total	CPNRD	TBNRD
2018	282.7	282.7	-
2019	21.5	21.5	-
2020	40.4	39.7	0.7
2021	196.4	196.4	-
2022	125.0	125.0	-
2023	70.8	70.8	-
Total	736.8	736.1	0.7

Data Source Discussion for Table 1 Column C

Table 4 summarizes the permanent retirement information provided in the datasets from CPNRD. Similar to the CREP/EQIP acreage, some permanent retirements occurred in cells assigned to neighboring NRDs. Note that Column A of Table 4 is the source of the information populated into Column C of Table 1.

Table 4. Summary of CPNRD permanent retirement acreage.

Year	(A) = B + C CPNRD Retirements	(B) Water Bank Only	(C) Water Bank And Offset Acres	LLNRD	TBNRD
2006	150.1	-	150.1	-	-
2007	-	-	-	-	-
2008	-	-	-	-	-
2009	1,513.8	75.0	1,438.8	0.4	149.1
2010	317.8	-	317.8	-	-
2011	430.8	-	430.8	-	-
2012	211.3	-	211.3	-	-
2013	19.1	-	19.1	-	-
Total	2,642.9	75.0	2,567.9	0.4	149.1

Note:
LLNRD – Lower Loup Natural Resources District
TBNRD – Tri-Basin Natural Resources District
(B) represents the data found only in the WB Purchases shapefile
(C) represents the intersection of the Acres Offset data set and the WB Purchases shapefiles limited to groundwater only transactions

The 140.3 acres converted from temporary to permanent as discussed in the Section above are reflected in this table.

Data Source Discussion for Table 1 Columns D and E

Table 5 summarizes the amount of new irrigated acreage resulting from CPNRD transfers, while Table 6 summarizes the amount of irrigated acreage reduced as a result of transfers occurring in the CPNRD.

Table 5. Summary of CPNRD added acres.

Year	Total	CPNRD	UBBNRD	LBNRD	LLNRD	LPNNRD	TBNRD
2011	1,107.4	1,087.2	5.1	10.6	4.5	-	-
2012	4,455.9	4,397.8	4.4	2.5	49.4	1.8	-
2013	4,268.9	4,255.3	10.0	-	2.2	-	1.4
Total	9,832.2	9,740.3	19.5	13.1	56.1	1.8	1.4

Table 6. Summary of CPNRD offset acres.

Year	Total	CPNRD	UBBNRD	LLNRD	LPNNRD
2011	698.3	683.5	4.3	10.5	-
2012	1,037.9	1,021.6	5.3	9.2	1.8
2013	1,445.2	1,440.0	2.9	2.3	-
Total	3,181.4	3,145.1	12.5	22.0	1.8

Note for Tables 5 and 6:
UBBNRD – Upper Big Blue Natural Resources District
LBNRD – Little Blue Natural Resources District
LLNRD – Lower Loup Natural Resources District
LPNNRD – Lower Platte North Natural Resources District
TBNRD – Tri-Basin Natural Resources District

Columns 'CPNRD' in Tables 5 and 6 are the sources for the information populated into Columns D and E, respectively, of Table 1. The tables also reflect a small amount of acreage attributed to cells assigned to neighboring NRDs due to the cell assignment process previously discussed.

Data Source Discussion for Table 1 Column F

Table 7 reflects, similar to how acreage modifications tracked by the CPNRD were located within cells assigned to other NRDs within the model, a small number of transactions tracked by the TPNRD (5.4 acres) and TBNRD (77.1 acres) that were placed into model cells which were assigned to the CPNRD. These transactions were all transfers away. The information in Column 'Total' of Table 7 is the source of the information populated into Column F of Table 1.

Table 7. Acreage summary of Non-CPNRD transactions which occurred within the CPNRD assigned cells.

Year	TPNRD	TBNRD	Total
2011	1.6	-	1.6
2012	3.8	-	3.8
2013	-	77.1	77.1
Total	5.4	77.1	82.5

Spatial Analysis Method

ArcGIS® was used to link the retirement, transfer, and variance information provided by CPNRD and NDNR to the COHYST 2010 model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

NDNR and CPNRD provided retirement and transfer acreage information in the form of shape files. The parcel information within the shape files was dissolved by year to remove duplicate areas. The offset acreage information was divided between transfers away and permanent retirements. The union function within ArcGIS® was applied to each shapefile to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS®.

Step 2: Building the Baseline Land Use

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update was the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of the investigation was the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all of the temporarily retired acres.

Acres were to be added or removed from their assigned cells. If there was insufficient space[1] for new acres or an insufficient amount of groundwater only acres[2] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[3]. This spatial process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom piece of FORTRAN script.

[1] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres
[2] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres
[3] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. 'r' and 'c' indicate the row column index of the cell.

The results of step 2 are shown in Table 8. As intended, the values in Column B of Table 8 match (sans de minimis rounding resulting from the distribution process) the original source information summarized in Column G of Table 1 for the years 2011-2023. This indicates that the acreage values provided by CPNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 8 also includes the changes attributable to the CPNRD which occur in cells assigned to its neighboring NRDs. Column C represents the total impact of Table 3 (Columns: TBNRD), Table 5 (Columns: UBBNRD, LBNRD, LLNRD, LPNNRD, & TBNRD), and Table 6 (Columns UBBNRD, LLNRD, & LPNNRD). It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 8. Change in groundwater only irrigated acres within the CPNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in CPNRD	(B) Annual Change in TPNRD Groundwater Only Irrigated Acres in the CPNRD	(C) Change in CPNRD Groundwater Only Irrigated Acres not in the CPNRD
2010	896,869.5	-	-
2011	896,840.8	(28.7)	5.4
2012	900,002.3	3,161.5	41.8
2013	902,721.3	2,719.0	8.4
2014	902,721.3	-	-
2015	902,721.3	-	-
2016	902,721.3	-	-
2017	902,721.3	-	-
2018	903,004.1	282.8	-
2019	903,025.6	21.5	-
2020	903,065.3	39.7	0.7
2021	903,261.7	196.4	-
2022	903,386.7	125.0	-
2023	903,457.5	70.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

A new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired. Other key elements of the scenario include:

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retired acres were added back in 2011 and remain moving forward.

Table 9 shows the change between the COHYST 2010 land use file and the unretired retirements scenario. The difference between the two data sets shows the cumulative change over time. Again, as intended, the annual change in ground water only irrigated acres shown on Table 8 Column D match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column G of Table 1 for the years 1999 through 2010 (the sign reversal indicates removal (unretirement) of the acreage). This indicates that the acreage values provided by the CPNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 9. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres within the CPNRD	
Year	(A) Run029	(B) Modified Land Use	(C) Cumulative	(D) Annual
1999	828,559	828,559	(0.0)	(0.0)
2000	834,741	834,741	-	0.0
2001	843,080	843,080	-	-
2002	854,133	854,133	0.0	0.0
2003	866,690	866,690	(0.0)	(0.0)
2004	878,324	878,324	-	0.0
2005	887,953	888,258	304.4	304.4
2006	883,622	884,337	715.1	410.7
2007	914,684	915,511	826.6	111.5
2008	877,717	878,597	879.5	52.9
2009	907,031	909,431	2,400.1	1,520.6
2010	896,870	899,587	2,717.9	317.8
		Cumulative		2,717.9

Table 10 shows the changes between the COHYST 2010 land use file and the land use file developed for the "unretired" condition within the Robust Review's retirement scenario. Column A in the table presents the annual acreage irrigated only with ground water from 2011 through 2023 for the "unretired" land use data set. Column B summarizes the acreage changes made to arrive at values presented in Column A. Columns C through I present the information used in the computation of the Column B values.

SUMMARY

Tables 8 through 10 summarize the background information as to how the land use files for the Robust Review will be populated. Comparisons back to Table 1 confirm the information provided to TFG by CPNRD, NDNR and other entities referenced in the memorandum were fully included in the model input files. The retirement scenario within the Robust Review involves two land use datasets: the Baseline Set; and the Unretired Set.

For the Baseline Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column A in Table 9 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 8 will be used

For the Unretired Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column B in Table 9 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 10 will be used

Table 10. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2023.

Year	(A) Groundwater Only Irrigated Acres	(B) Difference in Ground Water Only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away	(D) Transfers To	(E) Non Area Transfers Away	(F) Non Area Transfers To	(G) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Retirements
2011	899,989.5	402.1	683.5	1,087.2	1.6		(402.1)	(402.1)	(0.0)
2012	903,362.3	3,372.8	1,021.6	4,397.8	3.8		(3,372.4)	(3,774.5)	0.4
2013	906,100.4	2,738.1	1,440.0	4,255.3	77.1		(2,738.2)	(6,512.7)	(0.1)
2014	906,100.4	-					-	(6,512.7)	-
2015	906,100.4	-					-	(6,512.7)	-
2016	906,100.4	-					-	(6,512.7)	-
2017	906,100.4	-					-	(6,512.7)	-
2018	906,100.4	-					-	(6,512.7)	-
2019	906,100.4	-					-	(6,512.7)	-
2020	906,100.4	-					-	(6,512.7)	-
2021	906,100.4	-					-	(6,512.7)	-
2022	906,100.4	-					-	(6,512.7)	-
2023	906,100.4	-					-	(6,512.7)	-

Tables 11 and 12 show the annual area of groundwater only irrigated land for each county in the CPNRD within the Robust Review baseline and unretirement scenarios. Finally, Tables 13 and 14 show the annual area of groundwater only irrigated land for each county in the CPNRD and Platte River Drainage basin within the Robust Review's baseline and unretirement scenarios.

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	38,694	883	253	20,701	168	128	2,030
1951	38,107	596	26,837	-	40,090	897	220	18,343	170	118	1,864
1952	38,472	459	26,426	-	41,482	904	185	15,963	165	106	1,703
1953	38,638	665	26,443	-	42,875	781	120	13,606	160	84	1,541
1954	38,818	773	27,725	-	44,267	616	86	11,236	155	81	1,175
1955	42,204	1,217	35,398	58	51,750	915	233	16,096	202	143	2,394
1956	45,745	1,496	43,244	169	59,229	1,346	394	20,960	302	225	3,174
1957	49,510	1,920	50,498	281	66,706	2,042	554	25,719	402	308	3,861
1958	53,516	2,174	56,649	320	74,185	2,510	727	30,563	488	399	4,869
1959	57,358	2,538	64,005	467	81,662	2,990	891	35,406	552	463	5,867
1960	58,532	2,713	64,363	539	84,161	3,249	1,104	39,426	738	571	7,673
1961	59,699	2,720	64,418	743	86,660	3,536	1,307	43,459	922	697	9,349
1962	60,893	2,832	64,716	736	89,163	3,816	1,551	47,494	1,084	811	11,036
1963	62,188	2,897	65,266	757	91,656	4,062	1,823	51,508	1,218	960	12,692
1964	63,155	2,999	65,219	692	94,156	4,388	2,070	55,499	1,394	1,037	14,087
1965	67,131	4,116	67,466	1,321	98,490	4,867	3,070	60,697	1,750	1,245	16,472
1966	71,398	5,058	69,448	1,622	102,777	5,283	4,020	65,832	2,070	1,457	19,161
1967	75,375	5,991	71,862	1,604	107,112	5,667	4,808	70,912	2,482	1,747	21,573
1968	79,317	6,844	74,296	1,882	111,447	6,017	5,605	75,955	2,817	2,023	23,798
1969	83,508	7,897	76,595	1,952	115,722	6,698	6,275	80,999	3,128	2,247	26,254
1970	88,978	8,703	86,595	2,361	122,556	7,308	6,529	85,769	3,245	2,435	27,857
1971	94,430	9,677	96,852	2,716	129,273	7,958	7,032	90,528	3,276	2,591	29,419
1972	99,125	10,412	107,389	2,779	136,031	8,434	7,235	95,280	3,461	2,692	30,849
1973	104,220	11,069	117,907	3,115	142,807	8,882	7,548	99,922	3,715	2,769	32,414
1974	109,536	11,863	129,601	3,299	149,581	9,553	8,112	104,690	4,163	2,883	34,222
1975	116,243	12,546	132,081	3,729	156,915	10,270	8,995	111,897	4,829	3,245	36,893
1976	122,587	13,248	132,581	3,880	164,283	11,296	9,733	118,796	5,188	3,529	39,541
1977	129,105	14,362	135,105	4,265	171,636	11,780	10,114	125,820	5,644	3,975	42,361

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1978	136,078	15,494	136,151	4,481	178,967	12,647	10,967	132,888	6,213	4,204	44,679
1979	138,896	16,663	140,172	4,258	180,519	12,768	11,283	134,209	6,188	4,171	43,948
1980	142,065	17,443	145,645	4,369	182,018	12,827	11,613	135,467	6,268	4,117	42,961
1981	146,078	18,135	150,431	4,153	183,565	12,864	11,917	136,665	6,223	4,290	42,138
1982	149,224	18,722	155,109	4,352	184,999	12,810	12,157	137,922	6,293	4,277	41,025
1983	146,691	18,607	152,394	4,299	181,499	12,558	11,695	135,549	6,363	4,338	41,255
1984	143,647	17,959	149,510	4,114	177,862	12,243	11,303	133,139	6,457	4,412	41,345
1985	144,075	20,445	169,085	4,968	193,563	10,446	13,046	166,376	9,633	5,195	35,947
1986	144,745	20,080	166,815	4,908	193,519	10,344	12,745	166,499	9,564	5,214	36,157
1987	145,080	19,556	163,289	4,806	193,173	10,167	12,162	166,554	9,521	5,265	36,535
1988	146,473	19,684	163,270	4,856	194,271	10,219	12,616	167,318	9,446	5,278	36,357
1989	148,972	19,834	163,121	4,799	196,204	10,366	13,056	168,747	9,464	5,271	36,223
1990	150,649	20,009	163,019	4,738	197,294	10,424	13,501	170,202	9,556	5,280	36,063
1991	152,280	20,234	162,930	4,677	198,631	10,575	13,924	171,093	9,479	5,314	35,917
1992	154,498	20,827	163,529	4,657	200,312	10,817	14,723	172,140	9,447	5,388	35,536
1993	155,474	20,929	163,200	4,622	200,857	10,898	14,949	172,900	9,478	5,442	37,142
1994	156,701	21,061	162,887	4,588	201,279	10,984	15,203	173,400	9,534	5,495	38,749
1995	157,797	21,224	162,749	4,556	201,806	11,078	15,406	173,634	9,612	5,552	40,378
1996	159,570	21,437	163,209	4,545	203,009	11,177	15,653	174,129	9,791	5,615	42,052
1997	161,837	21,763	163,006	4,525	203,597	11,383	15,991	174,679	10,061	5,735	45,241
1998	162,219	21,787	167,423	4,818	203,667	11,425	16,038	174,203	10,129	5,900	45,809
1999	162,685	21,745	171,542	5,087	203,704	11,578	16,043	173,630	10,146	6,015	46,385
2000	163,257	21,718	175,831	5,334	204,223	11,686	16,186	173,201	10,178	6,203	46,924
2001	162,813	21,556	183,747	5,915	204,341	11,663	16,476	172,389	10,331	6,343	47,507
2002	164,295	22,660	186,859	6,214	205,180	11,707	16,511	174,074	10,446	6,470	49,718
2003	165,455	25,163	191,481	6,250	206,046	11,772	17,140	174,294	10,686	6,632	51,769
2004	166,787	26,266	195,741	6,499	207,343	11,986	17,765	174,759	10,936	6,664	53,578
2005	167,084	27,724	200,234	6,497	207,622	12,185	18,098	174,951	11,189	6,695	55,675

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2006	165,041	21,503	200,516	5,741	210,252	12,325	18,183	175,802	11,521	6,727	56,011
2007	171,270	26,613	211,532	6,538	213,805	12,740	19,019	177,883	12,213	6,862	56,209
2008	163,245	25,823	203,209	5,725	204,290	12,239	17,559	173,374	10,627	6,568	55,060
2009	170,387	27,559	211,181	6,394	208,849	12,622	18,390	176,557	11,693	6,801	56,597
2010	169,215	26,607	203,177	6,555	210,204	12,577	18,557	177,058	10,960	6,534	55,426
2011	169,132	26,591	202,848	6,551	210,356	12,714	18,650	177,059	10,978	6,534	55,427
2012	169,260	26,553	202,671	6,548	211,511	12,883	18,681	178,350	11,007	6,562	55,978
2013	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2014	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2015	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2016	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2017	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2018	169,508	26,552	202,910	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2019	169,508	26,552	202,931	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2020	169,508	26,552	202,971	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2021	169,508	26,552	203,167	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2022	169,508	26,552	203,292	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2023	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2024	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2025	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2026	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2027	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2028	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2029	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2030	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2031	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2032	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2033	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2034	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2035	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2036	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2037	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2038	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2039	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2040	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2041	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2042	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2043	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2044	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2045	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2046	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2047	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2048	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2049	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2050	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2051	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2052	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2053	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2054	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2055	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2056	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2057	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2058	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2059	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2060	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2061	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2062	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2063	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	38,694	883	253	20,701	168	128	2,030
1951	38,107	596	26,837	-	40,090	897	220	18,343	170	118	1,864
1952	38,472	459	26,426	-	41,482	904	185	15,963	165	106	1,703
1953	38,638	665	26,443	-	42,875	781	120	13,606	160	84	1,541
1954	38,818	773	27,725	-	44,267	616	86	11,236	155	81	1,175
1955	42,204	1,217	35,398	58	51,750	915	233	16,096	202	143	2,394
1956	45,745	1,496	43,244	169	59,229	1,346	394	20,960	302	225	3,174
1957	49,510	1,920	50,498	281	66,706	2,042	554	25,719	402	308	3,861
1958	53,516	2,174	56,649	320	74,185	2,510	727	30,563	488	399	4,869
1959	57,358	2,538	64,005	467	81,662	2,990	891	35,406	552	463	5,867
1960	58,532	2,713	64,363	539	84,161	3,249	1,104	39,426	738	571	7,673
1961	59,699	2,720	64,418	743	86,660	3,536	1,307	43,459	922	697	9,349
1962	60,893	2,832	64,716	736	89,163	3,816	1,551	47,494	1,084	811	11,036
1963	62,188	2,897	65,266	757	91,656	4,062	1,823	51,508	1,218	960	12,692
1964	63,155	2,999	65,219	692	94,156	4,388	2,070	55,499	1,394	1,037	14,087
1965	67,131	4,116	67,466	1,321	98,490	4,867	3,070	60,697	1,750	1,245	16,472
1966	71,398	5,058	69,448	1,622	102,777	5,283	4,020	65,832	2,070	1,457	19,161
1967	75,375	5,991	71,862	1,604	107,112	5,667	4,808	70,912	2,482	1,747	21,573
1968	79,317	6,844	74,296	1,882	111,447	6,017	5,605	75,955	2,817	2,023	23,798
1969	83,508	7,897	76,595	1,952	115,722	6,698	6,275	80,999	3,128	2,247	26,254

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1970	88,978	8,703	86,595	2,361	122,556	7,308	6,529	85,769	3,245	2,435	27,857
1971	94,430	9,677	96,852	2,716	129,273	7,958	7,032	90,528	3,276	2,591	29,419
1972	99,125	10,412	107,389	2,779	136,031	8,434	7,235	95,280	3,461	2,692	30,849
1973	104,220	11,069	117,907	3,115	142,807	8,882	7,548	99,922	3,715	2,769	32,414
1974	109,536	11,863	129,601	3,299	149,581	9,553	8,112	104,690	4,163	2,883	34,222
1975	116,243	12,546	132,081	3,729	156,915	10,270	8,995	111,897	4,829	3,245	36,893
1976	122,587	13,248	132,581	3,880	164,283	11,296	9,733	118,796	5,188	3,529	39,541
1977	129,105	14,362	135,105	4,265	171,636	11,780	10,114	125,820	5,644	3,975	42,361
1978	136,078	15,494	136,151	4,481	178,967	12,647	10,967	132,888	6,213	4,204	44,679
1979	138,896	16,663	140,172	4,258	180,519	12,768	11,283	134,209	6,188	4,171	43,948
1980	142,065	17,443	145,645	4,369	182,018	12,827	11,613	135,467	6,268	4,117	42,961
1981	146,078	18,135	150,431	4,153	183,565	12,864	11,917	136,665	6,223	4,290	42,138
1982	149,224	18,722	155,109	4,352	184,999	12,810	12,157	137,922	6,293	4,277	41,025
1983	146,691	18,607	152,394	4,299	181,499	12,558	11,695	135,549	6,363	4,338	41,255
1984	143,647	17,959	149,510	4,114	177,862	12,243	11,303	133,139	6,457	4,412	41,345
1985	144,075	20,445	169,085	4,968	193,563	10,446	13,046	166,376	9,633	5,195	35,947
1986	144,745	20,080	166,815	4,908	193,519	10,344	12,745	166,499	9,564	5,214	36,157
1987	145,080	19,556	163,289	4,806	193,173	10,167	12,162	166,554	9,521	5,265	36,535
1988	146,473	19,684	163,270	4,856	194,271	10,219	12,616	167,318	9,446	5,278	36,357
1989	148,972	19,834	163,121	4,799	196,204	10,366	13,056	168,747	9,464	5,271	36,223
1990	150,649	20,009	163,019	4,738	197,294	10,424	13,501	170,202	9,556	5,280	36,063
1991	152,280	20,234	162,930	4,677	198,631	10,575	13,924	171,093	9,479	5,314	35,917
1992	154,498	20,827	163,529	4,657	200,312	10,817	14,723	172,140	9,447	5,388	35,536
1993	155,474	20,929	163,200	4,622	200,857	10,898	14,949	172,900	9,478	5,442	37,142
1994	156,701	21,061	162,887	4,588	201,279	10,984	15,203	173,400	9,534	5,495	38,749
1995	157,797	21,224	162,749	4,556	201,806	11,078	15,406	173,634	9,612	5,552	40,378
1996	159,570	21,437	163,209	4,545	203,009	11,177	15,653	174,129	9,791	5,615	42,052
1997	161,837	21,763	163,006	4,525	203,597	11,383	15,991	174,679	10,061	5,735	45,241

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1998	162,219	21,787	167,423	4,818	203,667	11,425	16,038	174,203	10,129	5,900	45,809
1999	162,685	21,745	171,542	5,087	203,704	11,578	16,043	173,630	10,146	6,015	46,385
2000	163,257	21,718	175,831	5,334	204,223	11,686	16,186	173,201	10,178	6,203	46,924
2001	162,813	21,556	183,747	5,915	204,341	11,663	16,476	172,389	10,331	6,343	47,507
2002	164,295	22,660	186,859	6,214	205,180	11,707	16,511	174,074	10,446	6,470	49,718
2003	165,455	25,163	191,481	6,250	206,046	11,772	17,140	174,294	10,686	6,632	51,769
2004	166,787	26,266	195,741	6,499	207,343	11,986	17,765	174,759	10,936	6,664	53,578
2005	167,084	27,724	200,538	6,497	207,622	12,185	18,098	174,951	11,189	6,695	55,675
2006	165,051	21,503	201,221	5,741	210,252	12,325	18,183	175,802	11,521	6,727	56,011
2007	171,281	26,613	212,348	6,538	213,805	12,740	19,019	177,883	12,213	6,862	56,209
2008	163,255	25,823	204,078	5,725	204,290	12,239	17,559	173,374	10,627	6,568	55,060
2009	170,742	27,559	213,010	6,394	209,065	12,622	18,390	176,557	11,693	6,801	56,597
2010	169,571	26,607	205,256	6,555	210,432	12,577	18,557	177,113	10,960	6,534	55,426
2011	169,536	26,597	205,255	6,551	210,633	12,714	18,650	177,114	10,978	6,534	55,427
2012	169,707	26,559	205,247	6,548	211,787	12,883	18,681	178,405	11,007	6,562	55,978
2013	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2014	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2015	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2016	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2017	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2018	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2019	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2020	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2021	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2022	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2023	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2024	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2025	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2026	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2027	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2028	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2029	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2030	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2031	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2032	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2033	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2034	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2035	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2036	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2037	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2038	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2039	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2040	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2041	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2042	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2043	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2044	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2045	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2046	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2047	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2048	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2049	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2050	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2051	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2052	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2053	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2054	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2055	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2056	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2057	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2058	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2059	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2060	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2061	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2062	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2063	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	37,736	883	253	20,580	147	128	1,993
1951	38,107	596	26,837	-	38,967	897	220	18,220	151	118	1,798
1952	38,427	459	26,426	-	40,282	848	185	15,861	147	106	1,643
1953	38,597	665	26,443	-	41,454	732	120	13,497	142	84	1,492
1954	38,666	773	27,722	-	42,551	581	86	11,113	141	81	1,130
1955	41,954	1,217	35,370	58	49,528	801	233	15,930	171	143	2,320
1956	45,461	1,496	43,159	169	56,170	1,009	394	20,720	269	225	3,061
1957	49,047	1,920	50,373	281	62,398	1,414	537	25,320	332	308	3,654
1958	53,017	2,174	56,490	320	69,341	1,734	684	30,108	402	399	4,614
1959	56,831	2,538	63,779	467	76,263	2,064	839	34,889	461	463	5,564
1960	58,002	2,713	64,133	539	78,417	2,243	1,042	38,829	618	571	7,274
1961	59,070	2,720	64,176	743	80,640	2,437	1,231	42,804	777	697	8,867

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1962	60,251	2,832	64,471	736	82,921	2,627	1,464	46,798	924	811	10,471
1963	61,508	2,897	65,015	757	85,219	2,794	1,726	50,688	1,055	960	12,021
1964	62,477	2,999	64,950	692	87,092	3,013	1,967	54,585	1,186	1,037	13,377
1965	66,237	4,116	67,193	1,321	90,683	3,336	2,934	59,623	1,479	1,245	15,514
1966	70,468	5,058	69,130	1,622	94,197	3,589	3,854	64,682	1,746	1,457	17,938
1967	74,334	5,991	71,527	1,604	97,700	3,941	4,620	69,571	2,128	1,747	20,017
1968	78,123	6,844	73,929	1,882	101,499	4,196	5,374	74,403	2,344	2,023	22,083
1969	82,200	7,897	76,229	1,952	105,122	4,571	6,004	79,254	2,629	2,247	24,402
1970	87,492	8,703	86,185	2,361	111,092	5,086	6,264	83,830	2,763	2,435	25,756
1971	92,693	9,677	96,303	2,716	116,659	5,494	6,653	88,377	2,817	2,591	27,204
1972	97,300	10,303	106,747	2,779	122,400	5,927	6,868	92,665	2,997	2,692	28,564
1973	102,091	10,972	117,177	3,115	128,025	6,208	7,180	97,095	3,239	2,769	29,910
1974	107,137	11,682	128,835	3,299	134,016	6,529	7,745	101,782	3,701	2,883	31,597
1975	113,477	12,343	131,307	3,729	140,112	7,102	8,629	108,551	4,351	3,245	33,686
1976	119,342	13,080	131,715	3,880	145,777	7,761	9,305	115,018	4,703	3,529	36,078
1977	125,234	14,189	134,265	4,265	151,367	8,165	9,700	121,795	5,013	3,975	38,676
1978	131,712	15,294	135,229	4,481	157,612	8,790	10,515	128,568	5,552	4,204	40,768
1979	134,109	16,383	139,184	4,258	158,836	8,821	10,721	129,758	5,521	4,118	40,194
1980	136,916	17,154	144,644	4,369	160,116	8,885	11,049	130,886	5,535	4,072	39,334
1981	140,740	17,830	149,214	4,153	161,744	8,916	11,280	132,063	5,515	4,060	38,683
1982	143,696	18,401	153,794	4,352	162,727	8,875	11,506	133,142	5,602	4,049	37,629
1983	141,431	18,283	151,087	4,299	160,240	8,682	11,062	130,910	5,657	4,100	37,832
1984	138,674	17,680	148,292	4,114	157,198	8,518	10,718	128,660	5,748	4,180	37,916
1985	136,892	20,044	167,652	4,968	164,849	7,076	12,491	159,367	8,353	4,601	32,525
1986	137,539	19,686	165,401	4,908	164,844	7,009	12,207	159,463	8,300	4,618	32,716
1987	137,860	19,173	161,908	4,806	164,424	6,891	11,651	159,519	8,269	4,663	33,058
1988	139,189	19,298	161,898	4,856	165,411	6,922	12,088	160,269	8,208	4,649	32,902

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1989	141,513	19,445	161,755	4,799	166,906	7,086	12,511	161,685	8,244	4,643	32,802
1990	143,133	19,617	161,661	4,738	167,819	7,123	12,947	162,973	8,355	4,653	32,667
1991	144,709	19,839	161,577	4,677	168,815	7,142	13,356	163,767	8,293	4,646	32,489
1992	146,861	20,421	162,174	4,657	170,202	7,228	14,126	164,798	8,275	4,614	32,151
1993	147,684	20,520	161,850	4,622	170,367	7,279	14,342	165,307	8,303	4,660	33,606
1994	148,773	20,652	161,543	4,588	170,656	7,333	14,596	165,575	8,352	4,705	35,069
1995	149,833	20,813	161,411	4,556	171,142	7,392	14,799	165,806	8,419	4,755	36,563
1996	151,466	21,029	161,880	4,545	172,077	7,454	15,043	166,300	8,594	4,809	38,025
1997	153,438	21,351	161,687	4,525	172,431	7,594	15,376	166,805	8,835	4,911	40,738
1998	153,705	21,350	166,075	4,818	172,379	7,688	15,424	166,293	8,909	5,024	41,170
1999	153,876	21,310	170,164	5,087	172,366	7,796	15,435	165,758	8,923	5,121	41,716
2000	154,472	21,287	174,425	5,334	172,745	7,855	15,322	165,360	8,952	5,298	42,152
2001	154,078	21,135	182,288	5,915	172,816	7,842	15,601	164,534	9,087	5,416	42,703
2002	155,328	22,224	185,387	6,214	173,663	7,867	15,643	166,170	9,211	5,535	44,593
2003	156,124	24,687	189,865	6,250	174,370	7,913	16,280	166,310	9,426	5,563	46,421
2004	156,962	25,772	194,100	6,499	175,299	8,107	16,838	166,791	9,655	5,590	48,099
2005	157,177	26,801	198,563	6,497	175,586	8,276	17,153	166,989	9,879	5,615	49,947
2006	154,900	20,584	199,009	5,741	178,511	7,959	17,187	166,481	10,006	5,660	49,706
2007	160,930	25,670	209,739	6,538	181,168	8,353	18,012	168,783	10,608	5,795	49,821
2008	153,153	24,885	201,452	5,725	174,109	8,007	16,653	164,037	9,180	5,501	48,657
2009	160,080	26,603	209,434	6,394	176,127	8,264	17,444	167,098	10,120	5,734	50,122
2010	158,798	25,652	201,420	6,555	177,806	8,207	17,572	167,891	9,470	5,467	49,036
2011	158,711	25,636	201,095	6,551	177,827	8,226	17,663	167,880	9,488	5,467	49,037
2012	158,839	25,598	200,918	6,548	178,849	8,366	17,694	169,017	9,517	5,494	49,507
2013	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2014	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2015	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2016	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2017	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2018	158,977	25,597	201,154	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2019	158,977	25,597	201,175	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2020	158,977	25,597	201,215	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2021	158,977	25,597	201,411	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2022	158,977	25,597	201,536	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2023	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2024	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2025	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2026	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2027	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2028	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2029	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2030	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2031	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2032	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2033	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2034	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2035	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2036	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2037	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2038	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2039	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2040	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2041	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2042	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2043	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2044	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2045	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2046	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2047	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2048	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2049	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2050	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2051	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2052	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2053	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2054	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2055	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2056	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2057	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2058	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2059	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2060	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2061	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2062	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2063	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	37,736	883	253	20,580	147	128	1,993
1951	38,107	596	26,837	-	38,967	897	220	18,220	151	118	1,798
1952	38,427	459	26,426	-	40,282	848	185	15,861	147	106	1,643
1953	38,597	665	26,443	-	41,454	732	120	13,497	142	84	1,492
1954	38,666	773	27,722	-	42,551	581	86	11,113	141	81	1,130
1955	41,954	1,217	35,370	58	49,528	801	233	15,930	171	143	2,320
1956	45,461	1,496	43,159	169	56,170	1,009	394	20,720	269	225	3,061
1957	49,047	1,920	50,373	281	62,398	1,414	537	25,320	332	308	3,654
1958	53,017	2,174	56,490	320	69,341	1,734	684	30,108	402	399	4,614
1959	56,831	2,538	63,779	467	76,263	2,064	839	34,889	461	463	5,564
1960	58,002	2,713	64,133	539	78,417	2,243	1,042	38,829	618	571	7,274
1961	59,070	2,720	64,176	743	80,640	2,437	1,231	42,804	777	697	8,867
1962	60,251	2,832	64,471	736	82,921	2,627	1,464	46,798	924	811	10,471
1963	61,508	2,897	65,015	757	85,219	2,794	1,726	50,688	1,055	960	12,021
1964	62,477	2,999	64,950	692	87,092	3,013	1,967	54,585	1,186	1,037	13,377
1965	66,237	4,116	67,193	1,321	90,683	3,336	2,934	59,623	1,479	1,245	15,514
1966	70,468	5,058	69,130	1,622	94,197	3,589	3,854	64,682	1,746	1,457	17,938
1967	74,334	5,991	71,527	1,604	97,700	3,941	4,620	69,571	2,128	1,747	20,017
1968	78,123	6,844	73,929	1,882	101,499	4,196	5,374	74,403	2,344	2,023	22,083
1969	82,200	7,897	76,229	1,952	105,122	4,571	6,004	79,254	2,629	2,247	24,402
1970	87,492	8,703	86,185	2,361	111,092	5,086	6,264	83,830	2,763	2,435	25,756
1971	92,693	9,677	96,303	2,716	116,659	5,494	6,653	88,377	2,817	2,591	27,204
1972	97,300	10,303	106,747	2,779	122,400	5,927	6,868	92,665	2,997	2,692	28,564
1973	102,091	10,972	117,177	3,115	128,025	6,208	7,180	97,095	3,239	2,769	29,910
1974	107,137	11,682	128,835	3,299	134,016	6,529	7,745	101,782	3,701	2,883	31,597
1975	113,477	12,343	131,307	3,729	140,112	7,102	8,629	108,551	4,351	3,245	33,686
1976	119,342	13,080	131,715	3,880	145,777	7,761	9,305	115,018	4,703	3,529	36,078

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1977	125,234	14,189	134,265	4,265	151,367	8,165	9,700	121,795	5,013	3,975	38,676
1978	131,712	15,294	135,229	4,481	157,612	8,790	10,515	128,568	5,552	4,204	40,768
1979	134,109	16,383	139,184	4,258	158,836	8,821	10,721	129,758	5,521	4,118	40,194
1980	136,916	17,154	144,644	4,369	160,116	8,885	11,049	130,886	5,535	4,072	39,334
1981	140,740	17,830	149,214	4,153	161,744	8,916	11,280	132,063	5,515	4,060	38,683
1982	143,696	18,401	153,794	4,352	162,727	8,875	11,506	133,142	5,602	4,049	37,629
1983	141,431	18,283	151,087	4,299	160,240	8,682	11,062	130,910	5,657	4,100	37,832
1984	138,674	17,680	148,292	4,114	157,198	8,518	10,718	128,660	5,748	4,180	37,916
1985	136,892	20,044	167,652	4,968	164,849	7,076	12,491	159,367	8,353	4,601	32,525
1986	137,539	19,686	165,401	4,908	164,844	7,009	12,207	159,463	8,300	4,618	32,716
1987	137,860	19,173	161,908	4,806	164,424	6,891	11,651	159,519	8,269	4,663	33,058
1988	139,189	19,298	161,898	4,856	165,411	6,922	12,088	160,269	8,208	4,649	32,902
1989	141,513	19,445	161,755	4,799	166,906	7,086	12,511	161,685	8,244	4,643	32,802
1990	143,133	19,617	161,661	4,738	167,819	7,123	12,947	162,973	8,355	4,653	32,667
1991	144,709	19,839	161,577	4,677	168,815	7,142	13,356	163,767	8,293	4,646	32,489
1992	146,861	20,421	162,174	4,657	170,202	7,228	14,126	164,798	8,275	4,614	32,151
1993	147,684	20,520	161,850	4,622	170,367	7,279	14,342	165,307	8,303	4,660	33,606
1994	148,773	20,652	161,543	4,588	170,656	7,333	14,596	165,575	8,352	4,705	35,069
1995	149,833	20,813	161,411	4,556	171,142	7,392	14,799	165,806	8,419	4,755	36,563
1996	151,466	21,029	161,880	4,545	172,077	7,454	15,043	166,300	8,594	4,809	38,025
1997	153,438	21,351	161,687	4,525	172,431	7,594	15,376	166,805	8,835	4,911	40,738
1998	153,705	21,350	166,075	4,818	172,379	7,688	15,424	166,293	8,909	5,024	41,170
1999	153,876	21,310	170,164	5,087	172,366	7,796	15,435	165,758	8,923	5,121	41,716
2000	154,472	21,287	174,425	5,334	172,745	7,855	15,322	165,360	8,952	5,298	42,152
2001	154,078	21,135	182,288	5,915	172,816	7,842	15,601	164,534	9,087	5,416	42,703
2002	155,328	22,224	185,387	6,214	173,663	7,867	15,643	166,170	9,211	5,535	44,593
2003	156,124	24,687	189,865	6,250	174,370	7,913	16,280	166,310	9,426	5,563	46,421

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2004	156,962	25,772	194,100	6,499	175,299	8,107	16,838	166,791	9,655	5,590	48,099
2005	157,177	26,801	198,867	6,497	175,586	8,276	17,153	166,989	9,879	5,615	49,947
2006	154,910	20,584	199,713	5,741	178,511	7,959	17,187	166,481	10,006	5,660	49,706
2007	160,941	25,670	210,555	6,538	181,168	8,353	18,012	168,783	10,608	5,795	49,821
2008	153,163	24,885	202,321	5,725	174,109	8,007	16,653	164,037	9,180	5,501	48,657
2009	160,434	26,603	211,264	6,394	176,315	8,264	17,444	167,098	10,120	5,734	50,122
2010	159,154	25,652	203,499	6,555	178,006	8,207	17,572	167,946	9,470	5,467	49,036
2011	159,116	25,642	203,502	6,551	178,075	8,226	17,663	167,935	9,488	5,467	49,037
2012	159,286	25,604	203,493	6,548	179,097	8,366	17,694	169,072	9,517	5,494	49,507
2013	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2014	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2015	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2016	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2017	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2018	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2019	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2020	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2021	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2022	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2023	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2024	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2025	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2026	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2027	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2028	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2029	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2030	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2031	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2032	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2033	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2034	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2035	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2036	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2037	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2038	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2039	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2040	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2041	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2042	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2043	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2044	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2045	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2046	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2047	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2048	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2049	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2050	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2051	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2052	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2053	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2054	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2055	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2056	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2057	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2058	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2059	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2060	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2061	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2062	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2063	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Memorandum

To:	John Thorburn – Tri-Basin NRD; Kari Burgert – NDNR
From:	The Flatwater Group, Inc.
Date:	10/17/2018
Subject:	COHYST Area Robust Review: TBNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (MPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Tri-Basin NRD (TBNRD).

To account for transfers, retirements, and variances within TBNRD, TFG's primary work tasks included evaluating and summarizing the available datasets related to transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013; and to then create a new land use data set for the unretired acreage scenario. For the first step in the process, TFG worked with NDNR and TBNRD to gather the land use data (retirements, transfers, and variances) and place it into summary tables by land use type. TFG's next steps were to perform geospatial analyses using ArcGIS to identify the location of each transaction. The geospatial analysis included a proximity function in the form of a custom Fortran program to determine the closest available model cells capable of accommodating the specified land use change.

This memorandum presents a series of tables which summarize the annual number of acres retired or transferred within the TBNRD, outlines the spatial analysis methodology, and ultimately summarizes the resultant land use files.

Land Use Summary Tables

Using information provided by TBNRD, NDNR, and other basin NRDs, TFG compiled a final summary of the retirements, transfers, and variances occurring within the TPNRD assigned model domain. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-10 below summarize the information provided to TFG. Tables 11-20 summarize the distribution of that information into the modeling input files.

Table 1 provides an overall summary of the retirement and transfer acreage source information relevant to the TBNRD received by TFG. Columns A through E on Table 1 summarize the information provided by TBNRD and NDNR. Columns F through I summarize information tracked by other basin NRDs, but whose spatial location upon distribution to the model placed acreage within the model domain assigned to the TBNRD. Subsequent tables will define the source(s) of this information.

Table 1. Summary of TBNRD acreage changes for implementation into the Robust Review.

Year	TBNRD Data					Non-TBNRD Data				(J) Change
	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Temporary Retirements	(G) Reinstated Temporary Retirements	(H) Permanent Retirements	(I) Transfers To	
Baseline Change	(-)	(+)	(-)	(+)	(-)	(-)	(+)	(-)	(+)	
1999	1.9	-	-	-	-	-	-	-	-	(1.9)
2000	293.6	-	-	-	-	-	-	-	-	(293.6)
2001	408.6	-	-	-	-	-	-	-	-	(408.6)
2002	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-
2004	77.5	-	-	-	-	-	-	-	-	(77.5)
2005	259.4	7.0	-	-	-	-	-	-	-	(252.4)
2006	163.9	-	-	-	-	-	-	-	-	(163.9)
2007	219.8	-	-	-	-	-	-	-	-	(219.8)
2008	697.8	77.5	73.1	-	-	-	-	-	-	(693.4)
2009	167.9	223.7	-	-	-	0.7	-	149.1	-	(94.0)
2010	127.3	423.6	-	-	-	-	-	-	-	296.3
2011	111.3	610.3	-	178.7	246.7	-	-	-	-	431.0
2012	-	427.5	-	118.3	118.3	-	-	-	-	427.5
2013	-	450.4	-	229.4	168.5	-	-	-	1.4	512.7
2014	-	142.1	-	-	-	-	-	-	-	142.1
2015	-	127.9	-	-	-	-	-	-	-	127.9
2016	-	-	-	-	-	-	-	-	-	-
2017	-	39.0	-	-	-	-	-	-	-	39.0
2018	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-	-	-

Table 1. Summary of TBNRD acreage changes for implementation into the Robust Review.

Year	TBNRD Data					Non-TBNRD Data				
	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Temporary Retirements	(G) Reinstated Temporary Retirements	(H) Permanent Retirements	(I) Transfers To	(J) Change
2021	-	-	-	-	-	-	0.7	-	-	0.7
2022	-	-	-	-	-	-	-	-	-	-
2023	-	-	-	-	-	-	-	-	-	-
Total	2,529.0	2,529.0	73.1	526.4	533.5	0.7	0.7	149.1	1.4	(227.9)

Data Source Discussion for Table 1 Columns A through C

The TBNRD provided several spreadsheets containing information which were used to populate Table 1. Ultimately, two spreadsheets provided by the TBNRD on 7/17/2017 to TFG served as the TBNRD source information for the table:

TBNRD AppendixI_Conservation practices.xlsx
Platte_CIA_Permits_Changes_updates.xlsx

A third spreadsheet, *Robust_COHYST_Platte_data.xlsx*, was also provided to TFG; however, information relevant to the Robust Review that was contained in that spreadsheet was also contained in the two above spreadsheets and thus *Robust_COHYST_Platte_data.xlsx* was not used as an independent source of information by TFG.

The spreadsheets summarized information related to multiple conservation programs and categorized information accordingly. For the purposes of the Robust Review, TFG needed to designate those categories as being either a retirement (either temporary or permanent) or a transfer. Tables 2-4 below provide a mapping of the categories which were assigned to either temporary or permanent retirements in Table 1. The column headers in the tables indicate the TBNRD assigned category mapped to the Table 1 column indicated by the title of the table. Those table titles are:

Table 2: Summary of temporary retirement acreage in the TBNRD - This is Column A in Table 1

Table 3: Summary of permanent retirement acreage in the TBNRD - This is Column C in Table 1

Table 4: Summary of temporary retirement acreage reinstated in the TBNRD - This is Column B in Table 1

Table 2. Summary of temporary retirement acreage in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
1999	-	1.9	-	-	-	-	1.9
2000	-	28.3	7.0	-	258.3	-	293.6
2001	-	-	-	-	408.6	-	408.6
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	77.5	-	-	77.5
2005	-	16.6	21.0	221.8	-	-	259.4
2006	-	-	17.9	116.0	-	30.0	163.9
2007	-	9.0	27.0	183.8	-	-	219.8
2008	126.8	-	13.0	400.5	-	157.5	697.8
2009	-	-	14.8	153.1	-	-	167.9
2010	-	-	-	127.3	-	-	127.3
2011	-	-	-	111.3	-	-	111.3
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

Table 3. Summary of permanent retirement acreage in the TBNRD

Year	Conservation Easements	Permanent Retirements
1999	-	-
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	73.1	73.1
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
Total	73.1	73.1

Table 4. Summary of temporary retirement acreage reinstated in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
2005	-	-	7.0	-	-	-	7.0
2006	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-
2008	-	-	-	77.5	-	-	77.5
2009	-	1.9	-	221.8	-	-	223.7
2010	-	28.3	21.0	116.0	258.3	-	423.6
2011	-	-	17.9	183.8	408.6	-	610.3
2012	-	-	27.0	400.5	-	-	427.5
2013	126.8	-	13.0	153.1	-	157.5	450.4
2014	-	-	14.8	127.3	-	-	142.1
2015	-	16.6	-	111.3	-	-	127.9
2016	-	-	-	-	-	-	-
2017	-	9.0	-	-	-	30.0	39.0
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

The information under the column names on Tables 2-4 all originated in the spreadsheets provided by the TBNRD with the exception of "DNR CREP/EQIP" which summarized processed information from NDNR. The spreadsheet *TBNRD AppendixI_Conservation practices .xlsx* contained the only reference to a category TFG assigned to permanent retirements. Key elements regarding that category along with a reference to the table the category is considered in are shown below.

Conservation Easements

- 2 entries
- Table 3

With regards to temporary retirement information from the TBNRD, following are a few key elements regarding each of those categories along with a reference to which table number(s) the category is considered. With the exception of the category "CRP Reinstatements", information for all categories was taken from the file *TBNRD AppendixI_Conservation practices .xlsx*. As indicated below, the "CRP Reinstatements" information was taken from *Platte_CIA_Permits_Changes_updates.xlsx.*

Conservation Corners

- Contracts are for 5 years
- 11 entries
- Table 2 & Table 4

Buffer Strips

- Contracts are for 10 years
- 6 entries
- Table 2 & Table 4

Pheasants Forever

- Contract are for 5 years
- 15 entries
- Table 2 & Table 4

CRP Reinstatements – (Note data source was *Platte_CIA_Permits_Changes_updates.xlsx*)

- Assumed 10 year contract duration – provided information only specified when the acres were reinstated. No contract start date information was provided.
- 4 entries
- Table 2 & Table 4

CREP

- 1 entry
- The CREP entry was for 30 acres for the period 2006-2016. This entry was also in the DNR data set. The DNR data set was used due to the accompanying shape file.
- Table 2

TBNRD EQIP (EQIP)

- Contracts appears to be for 4 years
- 95 entries. Entries were cross referenced with information provided by NDNR to ensure acreage was neither double accounted for nor overlooked.
- Table 2 & Table 4

With regards to the CREP and EQIP programs, as indicated in the above discussion TFG received information from both the TBNRD and NDNR. To supplement the information provided by TBNRD, NDNR provided the shape file *CREP* on 8/17/2017. It was augmented by the spreadsheet *20170829_COHYSTAreaMissingDates.xlsx* provided on 8/29/2017 which provided additional contract start/end dates that were missing from the shape file attribute information.

This shape file included the most up to date list of CREP and EQIP contracts available from NDNR at that time. TFG spatially queried the data in the CREP shape file to obtain only the parcels located within the TBNRD. That query returned 114 parcels. Those parcels all had designations of either CREP, EQIP, or TBEQIP. Table 5 shows the number of acres represented by those 114 parcels.

Table 5. DNR CREP and EQIP temporary retirements within the TBNRD.

Year	CREP	EQIP	TBEQIP
2005	-	169.7	-
2006	1,029.8	-	-
2007	416.7	-	-
2008	16.6	-	380.1
2009	-	-	-
2010	2.6	-	-
Total	1,465.7	169.7	380.1

For inclusion in the Robust Review. the information was further limited to:

- Contracts initiated prior to the end of 2013
- Parcels located within the drainage area of the Platte River
- Contracts referencing acreage only irrigated with ground water

As a final QC step, the remaining records were compared to the information contained in the TBNRD spreadsheet *TBNRD AppendixI_Conservation practices.xlsx,* sheets 'EQIP D land' and 'CREP Acres'. The location and contract timing of the 'EQIP D land' records did not overlap with records in CREP shape file. The entry from 'CREP Acres', however, did match a record in the CREP shapefile. TFG elected to use the entry from the CREP shape file due to the spatial definition provided in the shapefile.

At the conclusion of this process, 21 parcels remained and were considered in the Robust Review. Table 6 below shows the number of acres represented by those parcels and are the values shown in columns "DNR CREP/EQIP" on Tables 2 and 4.

Table 6. DNR CREP and EQIP temporary retirements within the Platte River Basin area of the TBNRD.

Year	CREP	TBEQIP	End Year
2005	-	-	
2006	30.0	-	2017
2007	-	-	
2008	-	157.5	2013
2009	-	-	
2010	-	-	
Total	30.0	157.5	

Data Source Discussion for Table 1 Columns D and E

The information presented in Columns D and E of Table 1 represents the available acreage transfer information which was all provided to TFG in the spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx*.

The spreadsheet contained information regarding two types of transfers. The first type of transfer involved moving the source of the irrigation water, while the field where the irrigation water was applied remains unchanged. This type of transfer did not require any action to be taken for the Robust Review. These transfers were listed in the sheets 'G Water Transf_Exsisting' and 'G Water Transfers' within *Platte_CIA_Permits_Changes_updates.xlsx.*

The second type of transfer involved transferring the location of where the irrigation water was applied. These types of transfers were recorded on sheet 'Acres Transfers' in spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx*. The spreadsheet listed records for 109 such transfers. Of these, 25 occurred within a time frame that could have potentially impacted the 2011-2013 irrigation seasons. These records were compared to information on file at NDNR and TFG received confirmation on 11/14/2017 via email from NDNR that the TBNRD and NDNR information was in general agreement. Columns A and B in Table 7 below summarize that information.

Table 7. Summary of transfer acres in the TBNRD

TBNRD			To		From	
Year	(A) To	(B) From	(C) Current Year	(D) Next Year	(E) Current Year	(F) Next Year
2010	74.4	75.7	48.7	25.7	50.0	25.7
2011	158.0	158.0	153.0	5.0	153.0	5.0
2012	188.4	194.1	113.3	75.1	113.3	80.8
2013	234.3	250.8	154.3	80.0	164.8	86.0

The transfers represented on Table 7 occurred on or after July 1, 2010 and before July 1, 2013. This was based upon the 'Date Approved' field in the spreadsheet (*Platte_CIA_Permits_Changes_updates.xlsx*) information. For the purposes of inclusion in the Robust Review, it was decided that If the transfer occurred after July 1, it was likely that the original field was still irrigated in the transfer year; as the late year transfers typically happened in the fall (October-December). For transfers occurring on or before July 1, it was assumed that irrigation water was applied in the alternate (transfer) location. Columns C through F on Table 7 present a breakdown of the acreage based on the July 1 implementation date. Columns C and D partition the "Transfer To" acreage (Column A) while Columns E and F partition the "Transfer From" acreage (Column B). Table 8 presents summarizes the transfer acreage amounts after the July 1 timing criteria is applied.

Table 8. Summary of transfer acres in the TBNRD adjusted for timing within the year.

Adjusted		
Year	To	From
2011	178.7	178.7
2012	118.3	118.3
2013	229.4	245.6

The spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx* also contained information on wells converted for use for irrigation to use for watering livestock. The tab 'Conversion' in the spreadsheet contained four such entries, two of which occurred in the 2011-2013 timeframe. For the purposes of the Robust Review, those transactions were considered to be transfers. Table 9 incorporates these conversions with the Table 8 transfer information to provide the total Transfer To (Column A) and Transfer Away (Column D) values reflected on Table 1.

Table 9. Summary of transfer acres in the TBNRD

Year	(A) Transfer To	(B) Transfer Away	(C) Conversions	(D) Total Transfer Away
2011	178.7	178.7	67.9	246.7
2012	118.3	118.3	-	118.3
2013	229.4	168.5[1]	-	168.5
Total	526.4	465.6	67.9	533.5

<u>Data Source Discussion for Table 1 Columns F through I</u>

In addition to the information provided by TBNRD, the Central Platte Natural Resources District (CPNRD) identified retirements, transfers, and variances which were placed in cells assigned to the TBNRD in the Platte Basin. This information included transfers to (CPNRD Acres Added), permanent retirements (CPNRD Acres Offset WB), and temporary retirements (CPNRD CREP). The scope of these transactions is defined in Table 10, and depict the Non-TBNRD data in Table 1.

Table 10. DNR CREP and EQIP temporary retirements within the Platte River drainage Basin.

Year	CPNRD Acres Added	CPNRD Acres Offset WB	CPNRD CREP Retirement	CPNRD CREP Reinstatement
2009	-	149.1	0.7	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	1.4	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-
2019	-	-	-	-
2020	-	-	-	-
2021	-	-	-	0.7

[1] Transfer acres were subject to the same limitations as CREP/EQIP acreage. Table 13 traces the source of the 168.5 value for 2013.

<u>Other Information Provided By TBNRD</u>

The spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx* contained some additional information which was not included into the current Robust Review. The sheet 'Variances' summarized actions taken by the TBNRD which categorized as Variances. These actions tended to be administrative in nature rather than identifying acreage type changes. The POAC group decided in August 2017 to not consider these types of actions in the current Robust Review project.

The same spreadsheet also contained a sheet named 'Corrections' which contained a set of information regarding administrative changes related to the number of irrigated acres rather than changes to acreage locations. No action was taken on these entries.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers and variances to the COHYST model grid. This was accomplished either by overlaying the parcels' shape file with the model grid or linking the parcels' legal description to model cells.

Step 1: Assigning land use change locations within the model

Each of the transactions provided by TBNRD included a legal description. These descriptions typically included the quarter section in which the transaction took place. This information was linked to the COHYST 2010 model grid. COHYST uses a grid of 160-acre sized model cells; but, the cell boundaries and the section lines do not overlap. To accommodate this, the section shape file was spatially joined with the cell centroid. Typically, this would result in 4 cells being assigned to a section as represented on Table 11. Using the quarter section identifier, the cell which best represented the spatial location of the transaction was assigned the placement.[2]

Table 11. Approach used to link legal descriptions to model cell locations.

Cell Index	Row	Column	Quarter
Cell	x	y	NW
Cell + 1	x	y + 1	NE
Cell + 504	x + 1	y	SW
Cell + 505	x + 1	y + 1	SE

In a similar way the model cells were assigned to counties, NRDs, and drainage basins. In general, features were assigned to cells based on the location of the cell's centroid in relation to the border of interest. This results in a model cell being assigned a single value for a given feature class. For example, if the border of an NRD passes through a model cell, whichever NRD the cell's centroid is within determines which NRD the cell is assigned to within the model. For this reason, it is possible to have an activity which occurs within a cell along a feature border to be enacted by one entity that shares the border, but for the model to summarize the activity to the other entity which shares the border.

The data on Table 12 below illustrates just that type of effect. The acreage retirement information in Column A of Table 12 matches that shown in the 'TBNRD EQIP' column of Table 2. These again are retirements related to the EQIP program initiated by the TBNRD within the Platte Basin area of the District. However, when these actions are assigned within the model, a small number of acres are assigned to cells which have been assigned to a river basin outside of the Platte Basin. Columns B and C in Table 12 present the effect of this distribution within the model (Column B – acreage distributed to cells assigned within the model to be in the Platte Basin drainage area; Column C – acreage distributed to cells assigned within the model to a drainage basin outside of the Platte Basin). Likewise, Column D matches the acreage reinstatement information shown in the 'TBNRD EQIP' column of Table 4. Columns E and F reflect the distribution of that acreage inside of and outside of the Platte Basin, respectively.

[2] For irregular sections, the cell-section relationship and professional judgement was used to place the transaction acres as close as possible to the defined location.

Table 12. Distribution of the TBNRD EQIP acres between the Platte River Basin and the rest of the NRD[3].

Year	(A) Total EQUP TBNRD Retirements	(B) EQIP TBNRD Platte Basin Retirements	(C) EQIP TBNRD Non-Platte Basin Retirements	(D) Total EQUP TBNRD Reinstatements	(E) EQIP TBNRD Platte Basin Reinstatements	(F) EQIP TBNRD Non-Platte Basin Reinstatements
2004	77.5	50.0	27.5	-	-	-
2005	221.8	221.8	-	-	-	-
2006	116.0	116.0	-	-	-	-
2007	183.8	183.8	-	-	-	-
2008	400.5	400.5	-	77.5	50.0	27.5
2009	153.1	116.1	37.0	221.8	221.8	-
2010	127.3	127.3	-	116.0	116.0	-
2011	111.3	111.3	-	183.8	183.8	-
2012	-	-	-	400.5	400.5	-
2013	-	-	-	153.1	116.1	37.0
2014	-	-	-	127.3	127.3	-
2015	-	-	-	111.3	111.3	-
Total	1,391.3	1,326.8	64.5	1,391.3	1,326.8	64.5

The distribution of the Transfer Acres summarized in Table 8 encountered a similar issue. The acreage values in Column A on Table 13 matches those shown in the column 'From' in Table 8. Columns B and C in Table 13 reflect the distribution of those acres to cells defined as being either within the CPNRD (Column B) or the TBNRD (Column C). The acreage listed in Column C is then summarized based on whether the distribution placed the acreage within cells identified as being within either the Platte Basin (Column D) or outside of the Platte Basin (Column E) areas of the TBNRD.

Table 13. Distribution of TBNRD transfers away between applied NRDs and river basins[4].

Year	(A) Transfer Away Total	(B) Applied in CPNRD	(C) Applied In TBNRD	(D) TBNRD Platte	(E) TBNRD Non-Platte
2011	178.7	-	178.7	178.7	-
2012	118.3	-	118.3	118.3	-
2013	245.6	77.1	168.5	160.3	8.2

[3]TBNRD only provided EQIP contracts acreage for the Platte River Basin. However, some of these acres, while in the Platte Basin, were assigned to cells which were not in the Platte Basin. This is caused by the drainage boundary differing from cell boundaries.

[4] TBNRD only provided transfer acreage for the Platte River Basin. However, some of these acres, while in the Platte Basin, were assigned to cells which were not in the Platte Basin. This is caused by the drainage boundary differing from cell boundaries.

Step 2: Building the Baseline Land Use Update

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update is the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all the temporarily retired acres.[5]

Acres were to be added or removed from their assigned cells. If there was insufficient space[6] for new acres or an insufficient amount of groundwater only acres[7] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[8]. This spatial analysis process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. This occurs unless an even split would exceed the available space within a given cell at which time the placed acres would be limited to the available space and the remaining acres would be evenly split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom FORTRAN script.

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres.

[5] 2023 was identified as the year the last temporary retirement would be actively irrigated again for the first time
[6] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres
[7] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres
[8] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

The results of Step 2 are shown in Table 14. As intended, the values in Column B of Table 14 match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column J of Table 1 for the years 2011-2023. This indicates that the acreage values provided by TBNRD and NDNR were the quantities by which the modeling input files were adjusted. The value in Column C of Table 14 matches the value in Column B of Table 13 which again indicates that the model input files were adjusted by the intended values based on the results of the spatial distribution assignments made to the provided input data from TBNRD. As an aside, the distribution routines placed 58.6 of the 77.1 acres shown in Table 14 Column C into Dawson county and the remaining 18.5 acres into Buffalo county.

Table 14. Change in groundwater only irrigated acres within the TBNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in TBNRD	(B) Annual Change in TBNRD Groundwater Only Irrigated Acres in the TBNRD	(C) Change in TBNRD Groundwater Only Irrigated Acres not in the TBNRD
2010	459,902.8	-	-
2011	460,333.9	431.1	-
2012	460,761.2	427.3	-
2013	461,273.7	512.5	(77.1)
2014	461,415.8	142.1	-
2015	461,543.7	127.9	-
2016	461,543.7	-	-
2017	461,582.7	39.0	-
2018	461,582.7	-	-
2019	461,582.7	-	-
2020	461,582.7	-	-
2021	461,583.4	0.7	-
2022	461,583.4	-	-
2023	461,583.4	-	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

Similarly, a new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired. Other key elements of the scenario include:

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retired acres added back in 2011 remain moving forward.

Table 15 shows the changes between the COHYST 2010 land use data set (Column A) and the unretired retirements scenario data set (Column B). The difference between the two data sets is a result of incorporating the retirement and transfer acreage information into the model. Again as intended, the annual change in ground water only acres shown on Table 15 (Column D) match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column J of Table 1 for the years 2009-2010 (the sign reversal indicates removal (unretirement) of the acreage). This indicates that the acreage values provided by TBNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 15. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres	
Year	(A) Run029	(B) Modified Land Use	(C) Cumulative	(D) Annual
1999	408,126	408,128	1.9	1.9
2000	409,469	409,764	295.5	293.6
2001	409,418	410,122	704.1	408.6
2002	421,829	422,533	704.1	0.0
2003	422,302	423,007	704.2	0.1
2004	423,360	424,142	781.8	77.6
2005	422,424	423,458	1,033.9	252.1
2006	439,644	440,842	1,197.9	164.0
2007	464,704	466,122	1,418.0	220.1
2008	444,988	447,099	2,111.4	693.4
2009	471,247	473,452	2,204.8	93.4
2010	459,903	461,811	1,908.6	(296.2)
		Cumulative		1,908.6

Table 16 shows the changes between the annual COHYST 2010 land use files and the land use files developed for the “unretired” condition within the Robust Review’s retirement scenario. Column A in the table presents the annual acreage irrigated only with ground water from 2011 through 2023 for the “unretired” land use data set. Column B summarizes the acreage changes made to arrive at values presented in Column A. Columns C through J present the information used in the computation of the Column B values.

SUMMARY

Tables 14 through 16 summarize the background information as to how the land use files for the Robust Review will be populated. Comparisons back to Table 1 confirm the information provided to TFG by TBNRD, NDNR and other entities referenced in the memorandum were fully included in the model input files. The retirement scenario within the Robust Review involves two land use datasets: the Baseline Set; and the Unretired Set.

For the Baseline Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column A in Table 15 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 14 will be used

For the Unretired Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column B in Table 15 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 16 will be used

Table 16. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2017.

Year	(A) Groundwater Only Irrigated Acres	(B) =I-G+J Difference in Groundwater only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away (Table 9, Col D And Table 13, Col D)	(D) Transfers to (Table 9, Col A)	(E) Non Area Transfers Away (Table 13, Col E)	(F) Non Area Transfers To (Table 10)	(G) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Reinstated Temporary Retirements (Table 2)	(J) Residuals
2011	461,854.8	43.8	246.7[9]	178.7	-	-	67.9	67.9	111.3	0.4
2012	461,854.7	(0.1)	118.3[10]	118.3	-	-	-	67.9	-	(0.1)
2013	461,916.9	62.2	160.3[11]	229.4	8.2	1.4	(62.3)	5.7	-	(0.1)
2014	461,916.9	-					-	5.7		-
2015	461,916.9	-					-	5.7		-
2016	461,916.9	-					-	5.7		-
2017	461,916.9	-					-	5.7		-
2018	461,916.9	-					-	5.7		-
2019	461,916.9	-					-	5.7		-
2020	461,916.9	-					-	5.7		-
2021	461,916.9	-					-	5.7		-
2022	461,916.9	-					-	5.7		-
2023	461,916.9	-					-	5.7		-

[9] Table 9, Column D
[10] Table 9, Column D
[11] Table 13, Column D

Tables 17 and 18 show the annual area of groundwater only irrigated land for each county in the TBNRD within the Robust Review's baseline and unretirement scenarios. Finally, Tables 19 and 20 show the annual area of groundwater only irrigated land for each county in the TBNRD within the Platte River Drainage basin.

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,325	165,623
2000	64,020	179,822	165,627
2001	64,705	179,524	165,188
2002	65,456	187,438	168,936
2003	66,229	187,575	168,498
2004	67,007	187,705	168,648
2005	67,899	187,429	167,096
2006	70,272	196,922	172,450
2007	85,141	200,533	179,031
2008	74,647	198,594	171,748
2009	91,432	200,132	179,683
2010	83,058	197,888	178,957
2011	83,049	198,313	178,972
2012	83,156	198,376	179,230
2013	83,199	198,508	179,567
2014	83,274	198,508	179,634
2015	83,274	198,524	179,746
2016	83,274	198,524	179,746
2017	83,274	198,524	179,785
2018	83,274	198,524	179,785
2019	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,327	165,623
2000	64,020	180,099	165,646
2001	64,705	180,210	165,207
2002	65,456	188,123	168,955
2003	66,229	188,261	168,517
2004	67,007	188,468	168,667
2005	67,906	188,232	167,320
2006	70,330	197,742	172,769
2007	85,216	201,384	179,523
2008	74,828	199,550	172,721
2009	91,811	201,080	180,561
2010	83,454	198,549	179,809
2011	83,428	198,529	179,898
2012	83,428	198,529	179,898
2013	83,423	198,598	179,896
2014	83,423	198,598	179,896
2015	83,423	198,598	179,896
2016	83,423	198,598	179,896
2017	83,423	198,598	179,896
2018	83,423	198,598	179,896
2019	83,423	198,598	179,896

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2020	83,274	198,524	179,785
2021	83,274	198,524	179,785
2022	83,274	198,524	179,785
2023	83,274	198,524	179,785
2024	83,274	198,524	179,785
2025	83,274	198,524	179,785
2026	83,274	198,524	179,785
2027	83,274	198,524	179,785
2028	83,274	198,524	179,785
2029	83,274	198,524	179,785
2030	83,274	198,524	179,785
2031	83,274	198,524	179,785
2032	83,274	198,524	179,785
2033	83,274	198,524	179,785
2034	83,274	198,524	179,785
2035	83,274	198,524	179,785
2036	83,274	198,524	179,785
2037	83,274	198,524	179,785
2038	83,274	198,524	179,785
2039	83,274	198,524	179,785
2040	83,274	198,524	179,785
2041	83,274	198,524	179,785
2042	83,274	198,524	179,785
2043	83,274	198,524	179,785
2044	83,274	198,524	179,785
2045	83,274	198,524	179,785
2046	83,274	198,524	179,785
2047	83,274	198,524	179,785
2048	83,274	198,524	179,785
2049	83,274	198,524	179,785
2050	83,274	198,524	179,785
2051	83,274	198,524	179,785
2052	83,274	198,524	179,785
2053	83,274	198,524	179,785
2054	83,274	198,524	179,785
2055	83,274	198,524	179,785
2056	83,274	198,524	179,785
2057	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
2020	83,423	198,598	179,896
2021	83,423	198,598	179,896
2022	83,423	198,598	179,896
2023	83,423	198,598	179,896
2024	83,423	198,598	179,896
2025	83,423	198,598	179,896
2026	83,423	198,598	179,896
2027	83,423	198,598	179,896
2028	83,423	198,598	179,896
2029	83,423	198,598	179,896
2030	83,423	198,598	179,896
2031	83,423	198,598	179,896
2032	83,423	198,598	179,896
2033	83,423	198,598	179,896
2034	83,423	198,598	179,896
2035	83,423	198,598	179,896
2036	83,423	198,598	179,896
2037	83,423	198,598	179,896
2038	83,423	198,598	179,896
2039	83,423	198,598	179,896
2040	83,423	198,598	179,896
2041	83,423	198,598	179,896
2042	83,423	198,598	179,896
2043	83,423	198,598	179,896
2044	83,423	198,598	179,896
2045	83,423	198,598	179,896
2046	83,423	198,598	179,896
2047	83,423	198,598	179,896
2048	83,423	198,598	179,896
2049	83,423	198,598	179,896
2050	83,423	198,598	179,896
2051	83,423	198,598	179,896
2052	83,423	198,598	179,896
2053	83,423	198,598	179,896
2054	83,423	198,598	179,896
2055	83,423	198,598	179,896
2056	83,423	198,598	179,896
2057	83,423	198,598	179,896

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2058	83,274	198,524	179,785
2059	83,274	198,524	179,785
2060	83,274	198,524	179,785
2061	83,274	198,524	179,785
2062	83,274	198,524	179,785
2063	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
2058	83,423	198,598	179,896
2059	83,423	198,598	179,896
2060	83,423	198,598	179,896
2061	83,423	198,598	179,896
2062	83,423	198,598	179,896
2063	83,423	198,598	179,896

*Up to 70 acres occur in a cell assigned to TBNRD and Frontier County. This data was combined into the Gosper County total.

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1950	-	1,451	2,284
1951	-	2,756	2,526
1952	-	4,471	2,559
1953	-	5,672	3,353
1954	-	6,037	4,573
1955	-	8,107	5,669
1956	-	9,964	7,426
1957	-	11,608	10,599
1958	-	13,579	10,809
1959	695	15,597	11,822
1960	1,305	15,765	12,299
1961	1,826	15,948	13,191
1962	2,290	15,959	13,547
1963	2,819	16,120	15,229
1964	3,262	16,387	16,483
1965	4,568	19,419	20,599
1966	6,203	21,983	25,050
1967	7,199	24,714	28,886
1968	8,025	26,725	32,380
1969	8,997	29,610	36,325
1970	9,808	31,757	38,917
1971	10,618	34,429	41,562
1972	10,753	37,051	45,541

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1950	-	1,451	2,284
1951	-	2,756	2,526
1952	-	4,471	2,559
1953	-	5,672	3,353
1954	-	6,037	4,573
1955	-	8,107	5,669
1956	-	9,964	7,426
1957	-	11,608	10,599
1958	-	13,579	10,809
1959	695	15,597	11,822
1960	1,305	15,765	12,299
1961	1,826	15,948	13,191
1962	2,290	15,959	13,547
1963	2,819	16,120	15,229
1964	3,262	16,387	16,483
1965	4,568	19,419	20,599
1966	6,203	21,983	25,050
1967	7,199	24,714	28,886
1968	8,025	26,725	32,380
1969	8,997	29,610	36,325
1970	9,808	31,757	38,917
1971	10,618	34,429	41,562
1972	10,753	37,051	45,541

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1973	11,543	38,343	48,751
1974	12,240	40,953	53,046
1975	13,730	43,895	58,392
1976	15,050	46,039	62,503
1977	15,785	47,810	67,858
1978	16,792	50,036	71,705
1979	17,321	52,080	75,671
1980	17,678	55,399	79,706
1981	18,191	57,014	81,229
1982	18,530	58,737	83,636
1983	18,829	58,430	84,575
1984	18,824	57,783	84,309
1985	18,855	56,061	82,805
1986	18,668	55,868	82,479
1987	16,997	55,412	81,675
1988	17,219	56,116	82,625
1989	17,767	56,887	84,145
1990	18,190	57,348	85,113
1991	18,662	58,639	85,833
1992	19,290	60,028	87,456
1993	19,225	60,647	88,224
1994	19,512	61,398	88,644
1995	19,482	61,940	89,048
1996	19,777	62,572	89,715
1997	19,826	63,559	90,195
1998	21,061	63,366	90,027
1999	21,145	63,384	89,796
2000	21,261	63,445	89,849
2001	21,240	63,304	89,638
2002	20,818	66,058	91,450
2003	20,419	65,563	91,187
2004	20,024	65,338	90,602
2005	19,739	66,054	90,123
2006	20,443	67,863	93,694
2007	23,309	69,246	96,783
2008	19,770	67,654	94,781
2009	24,102	68,433	97,068

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1973	11,543	38,343	48,751
1974	12,240	40,953	53,046
1975	13,730	43,895	58,392
1976	15,050	46,039	62,503
1977	15,785	47,810	67,858
1978	16,792	50,036	71,705
1979	17,321	52,080	75,671
1980	17,678	55,399	79,706
1981	18,191	57,014	81,229
1982	18,530	58,737	83,636
1983	18,829	58,430	84,575
1984	18,824	57,783	84,309
1985	18,855	56,061	82,805
1986	18,668	55,868	82,479
1987	16,997	55,412	81,675
1988	17,219	56,116	82,625
1989	17,767	56,887	84,145
1990	18,190	57,348	85,113
1991	18,662	58,639	85,833
1992	19,290	60,028	87,456
1993	19,225	60,647	88,224
1994	19,512	61,398	88,644
1995	19,482	61,940	89,048
1996	19,777	62,572	89,715
1997	19,826	63,559	90,195
1998	21,061	63,366	90,027
1999	21,145	63,386	89,796
2000	21,261	63,722	89,867
2001	21,240	63,990	89,657
2002	20,818	66,744	91,469
2003	20,419	66,248	91,206
2004	20,024	66,076	90,621
2005	19,746	66,831	90,346
2006	20,501	68,656	94,013
2007	23,384	70,069	97,274
2008	19,952	68,610	95,747
2009	24,444	69,381	97,937

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2010	23,088	68,924	96,526
2011	23,080	69,349	96,541
2012	23,186	69,411	96,793
2013	23,192	69,552	97,129
2014	23,267	69,552	97,196
2015	23,267	69,568	97,307
2016	23,267	69,568	97,307
2017	23,267	69,568	97,346
2018	23,267	69,568	97,346
2019	23,267	69,568	97,346
2020	23,267	69,568	97,346
2021	23,268	69,568	97,346
2022	23,268	69,568	97,346
2023	23,268	69,568	97,346
2024	23,268	69,568	97,346
2025	23,268	69,568	97,346
2026	23,268	69,568	97,346
2027	23,268	69,568	97,346
2028	23,268	69,568	97,346
2029	23,268	69,568	97,346
2030	23,268	69,568	97,346
2031	23,268	69,568	97,346
2032	23,268	69,568	97,346
2033	23,268	69,568	97,346
2034	23,268	69,568	97,346
2035	23,268	69,568	97,346
2036	23,268	69,568	97,346
2037	23,268	69,568	97,346
2038	23,268	69,568	97,346
2039	23,268	69,568	97,346
2040	23,268	69,568	97,346
2041	23,268	69,568	97,346
2042	23,268	69,568	97,346
2043	23,268	69,568	97,346
2044	23,268	69,568	97,346
2045	23,268	69,568	97,346
2046	23,268	69,568	97,346

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2010	23,447	69,584	97,371
2011	23,421	69,565	97,459
2012	23,421	69,565	97,459
2013	23,417	69,641	97,458
2014	23,417	69,641	97,458
2015	23,417	69,641	97,458
2016	23,417	69,641	97,458
2017	23,417	69,641	97,458
2018	23,417	69,641	97,458
2019	23,417	69,641	97,458
2020	23,417	69,641	97,458
2021	23,417	69,641	97,458
2022	23,417	69,641	97,458
2023	23,417	69,641	97,458
2024	23,417	69,641	97,458
2025	23,417	69,641	97,458
2026	23,417	69,641	97,458
2027	23,417	69,641	97,458
2028	23,417	69,641	97,458
2029	23,417	69,641	97,458
2030	23,417	69,641	97,458
2031	23,417	69,641	97,458
2032	23,417	69,641	97,458
2033	23,417	69,641	97,458
2034	23,417	69,641	97,458
2035	23,417	69,641	97,458
2036	23,417	69,641	97,458
2037	23,417	69,641	97,458
2038	23,417	69,641	97,458
2039	23,417	69,641	97,458
2040	23,417	69,641	97,458
2041	23,417	69,641	97,458
2042	23,417	69,641	97,458
2043	23,417	69,641	97,458
2044	23,417	69,641	97,458
2045	23,417	69,641	97,458
2046	23,417	69,641	97,458

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2047	23,268	69,568	97,346
2048	23,268	69,568	97,346
2049	23,268	69,568	97,346
2050	23,268	69,568	97,346
2051	23,268	69,568	97,346
2052	23,268	69,568	97,346
2053	23,268	69,568	97,346
2054	23,268	69,568	97,346
2055	23,268	69,568	97,346
2056	23,268	69,568	97,346
2057	23,268	69,568	97,346
2058	23,268	69,568	97,346
2059	23,268	69,568	97,346
2060	23,268	69,568	97,346
2061	23,268	69,568	97,346
2062	23,268	69,568	97,346
2063	23,268	69,568	97,346

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2047	23,417	69,641	97,458
2048	23,417	69,641	97,458
2049	23,417	69,641	97,458
2050	23,417	69,641	97,458
2051	23,417	69,641	97,458
2052	23,417	69,641	97,458
2053	23,417	69,641	97,458
2054	23,417	69,641	97,458
2055	23,417	69,641	97,458
2056	23,417	69,641	97,458
2057	23,417	69,641	97,458
2058	23,417	69,641	97,458
2059	23,417	69,641	97,458
2060	23,417	69,641	97,458
2061	23,417	69,641	97,458
2062	23,417	69,641	97,458
2063	23,417	69,641	97,458

Memorandum

To: Ann Dimmit – TPNRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 10/17/2018
Subject: COHYST Area Robust Review: TPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Twin Platte NRD (TPNRD).

To account for transfers, retirements, and variances within the TPNRD, TFG's primary work tasks included evaluating and summarizing the available datasets related to transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013; and to then create a new land use data set for the unretired acreage scenario. For the first step in the process, TFG worked with NDNR and TPNRD to gather the land use data (retirements, transfers, and variances) and place into summary tables by land use type. TFG's next steps were to perform geospatial analyses using ArcGIS to identify the location of each transaction. The geospatial analysis included a proximity function in the form of a custom Fortran program to determine the closest available model cells capable of accommodating the specified land use change.

This memorandum presents a series of tables which summarize the annual number of acres retired or transferred within the TPNRD, outlines the spatial analysis methodology, and ultimately summarizes the resultant land use files.

Land Use Summary Tables

Using information provided by TPNRD and the NDNR, TFG compiled a final summary of the retirements, transfers, and variances for the TPNRD. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-4 below summarize the information provided to TFG. Tables 5-11 summarize the distribution of that information into the modeling input files.

Table 1 shows an overview summary of retirements and transfers in the TPNRD. Tables 2, 3, and 4 show summaries of the individual categories used to create Table 1 and serve as a reference for the description of each data source.

Table 1. Summary of TPNRD acreage changes for implementation into the Robust Review.

Year	Temporary Retirements	Reinstated Temporary Retirements	Transfers To	Transfers Away	Change
Baseline Change	(-)	(+)	(+)	(-)	
2006	595.5	-	-	-	(595.5)
2007	27.4	-	-	-	(27.4)
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	833.2	815.6	17.6
2012	40.8	28.8	1,569.5	1,635.5	(78.0)
2013	-	-	1,865.3	1,840.5	24.8
2014	-	-	-	-	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	-	594.1	-	-	594.1
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	-	-	-	-	-
2023	-	40.8	-	-	40.8
Total	663.7	663.7	4,268.0	4,291.6	(23.6)

The TPNRD provided two shape files on 8/8/2017 which summarized acreage transfers in the District:

TPNRD_Acres_Decertified_Implemented_through_2013 – (Transfers Away)

TPNRD_New_Acres_implemented_through_2013 – (Transfers To)

These two files provided the spatial location of the acreage transfers within the TPNRD.

Key elements from the information provided related to Decertified Acres (Transfers Away in Table 1):

- 229 entries
- 149 of the 229 entries occurred between 2011 and 2013
- Timing was based upon the implementation year
- In 2013, 234.3 decertified acres were located outside the COHYST 2010 active model domain. They were not considered when modifying the land use.
- 5.4 decertified acres were removed from cells assigned to the CPNRD; 1.6 acres in 2011 and 3.8 acres in 2012
- Table 2 summarizes the model areas impacted by the provided information

Key Elements form the information provided related to New Acres (Transfers To in Table 1):
- 187 entries
- 131 of the 187 entries occurred between 2011 and 2013
- Timing was based upon the implementation year
- 11.4 acres were added to cells assigned to the URNRD. All 11.4 acres were added in 2011.
- Table 3 summarizes the model areas impacted by the provided information

Table 2. Summary of decertified transfer acres in the TPNRD

Year	Decertified Acres	Decertified Acres in Non-Active Cells	Modeled Decertified Acres	Removed from TPNRD	Removed From CPNRD
2011	815.6	-	815.6	814.0	1.6
2012	1,635.5	-	1,635.5	1,631.7	3.8
2013	2,074.8	234.3	1,840.5	1,840.5	-
Total	4,525.9	234.3	4,291.6	4,286.2	5.4

Table 3. Summary of new transfer acres in the TPNRD

Year	New Acres	Added To TPNRD	Added to URNRD
2011	833.2	821.8	11.4
2012	1,569.5	1,569.5	-
2013	1,865.3	1,865.3	-
Total	4,268.0	4,256.6	11.4

Temporary retirement information recorded on Table 1 was based on information NDNR provided on 8/17/2017 in the form of a shape file which summarized CREP and EQIP contract information.

This shape file included the updated list of CREP and EQIP contracts. The data was clipped to the TPNRD resulting in 59 polygons totaling 1,641 acres. The information was limited to groundwater only irrigated (Irrigation = 1) lands which trimmed the area to 14 polygons and 905 acres. Finally, the polygons were reduced to those which were initiated prior to the 2013 irrigation season. This left the data set with 11 entries with 663.7 acres. Each of these 11 entries were CREP contracts. Contract lengths were either 5, 10, or 11 years (Table 4).

To be considered for the current year, the retirement needed to be initiated or ended prior to July of the current year; otherwise, the transaction will have its first effect in the next year. The rationale is that if the action was taken prior to July, the transaction could influence the irrigation season in the current year. However, if the transaction occurred later, the land would finish up the current growing season in the same state.

Table 4. Summary of temporary retirements and reinstated retirement acres in the TPNRD

Year	Temporary Retirements	Reinstated Retirements
2006	595.5	-
2007	27.4	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	40.8	28.8
2013	-	-
2014	-	-
2015	-	-
2016	-	-
2017	-	594.1
2018	-	-
2019	-	-
2020	-	-
2021	-	-
2022	-	-
2023	-	40.8
Total	663.7	663.7

As discussed above, the acreage summarized in Table 1 (developed from the information in Tables 2-4) was provided in a series of GIS shape files. Using standard GIS practices, the acreage polygons within these coverages were unioned with the COHYST 2010 model grid to determine the number of acres in each model grid cell for each transaction. The following section provides additional detail on this process.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers, and variances to the COHYST model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

NDNR and TPNRD provided shape files for their retirements and transfers. The union function within ArcGIS was applied to the shapefiles to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS.

Step 2: Building the Baseline Land Use

The next step was to build the 2011-2013 baseline land use files incorporating the identified transfers and retirements. The beginning condition for this update was the 2010 land use file from the COHYST 2010 model. Each of the transactions occurring in 2011 were applied to the existing 2010 land use file to create the 2011 land use file; which in turn became the basis for applying the transactions occurring in 2012. This continued through 2013. One of the key points of the investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 in order to accurately reflect the temporary nature of the retirements. [1]

In the process of distributing the GIS polygon information to the model cells, the existing acreage within a given cell in the year 2010 (as modified moving forward through 2013 as discussed above) was considered. If there was insufficient space[2] for new acres or an insufficient amount of groundwater only acres[3] to be retired within a given cell, the addition or subtraction of acres was applied to nearby cells which exhibited the appropriate characteristics[4]. This spatial analysis process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom FORTRAN script.

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[1] 2023 was identified as the year the last TPNRD temporary retirement would be actively irrigated again for the first time

[2] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres available

[3] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres identified

[4] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. 'r' and 'c' indicate the row column index of the cell.

Table 5 presents the results of Step 2 above. The values in Table 5 were generated by summarizing information from the model land use input files (created as described above) developed for the baseline (full representation of all acreage retirements/transfers) Robust Review model run. Comparing Table 5 to Table 1 shows how the provided information was ultimately represented in the model for the years 2011 – 2023. Discrepancies between the tables are generally related to a particular cell's NRD assignment within the model. In 2011, the location of a couple of transactions were placed in cells designated CPNRD or URNRD; 11.4 new acres were placed in the URNRD in Perkins County, while 1.6 acres were removed from CPNRD in Dawson County. Likewise, in 2012, 3.8 acres were removed from CPNRD in Dawson County. These placements were from the New Acres(Transfers To in Table 1) and Decertified Acres (Transfers Away in Table 1) data sets.

It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 5. Change in groundwater only irrigated acres within the TPNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in TPNRD	(B) Annual Change in TPNRD Groundwater Only Irrigated Acres in the TPNRD	(C) Change in TPNRD Groundwater Only Irrigated Acres not in the TPNRD
2010	263,165.7	-	-
2011	263,173.8	8.1	9.8
2012	263,099.6	(74.2)	(3.8)
2013	263,124.4	24.8	-
2014	263,124.4	-	-
2015	263,124.4	-	-
2016	263,124.4	-	-
2017	263,718.3	593.9	-
2018	263,718.3	-	-
2019	263,718.3	-	-
2020	263,718.3	-	-
2021	263,718.3	-	-
2022	263,718.3	-	-
2023	263,759.1	40.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

Step 3 was taken to develop a new set of land use files for the unretired scenario within the Robust Review. Key elements related to the construction of this scenario include:

a) Acreage transfers were applied as the historically occurred.
b) Post 2010, no acreage retirement activities were incorporated.
c) For temporary and permanent retirements initiated prior to 2010, irrigated acres were added back into the modified land use files starting with the first retirement year (e.g. if a retirement started in 2008, the retired acres were added back into the model starting in 2008).

Regarding c) above, Table 6 shows the changes between the COHYST 2010 land use (column “Run029” in Table 6) and the unretired retirements scenario (column “Modified Land Use” in Table 6). The difference between the two data sets shows the cumulative change over time. These values match those shown in Table 1 subject to rounding resulting from the distribution process.

Table 6. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

Year	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres within the TPNRD	
	Run 029	Modified Land Use	Cumulative	Annual
1999	208,718	208,718	-	-
2000	210,934	210,934	-	-
2001	213,311	213,311	-	-
2002	221,892	221,892	-	-
2003	233,442	233,442	-	-
2004	245,508	245,508	-	-
2005	250,480	250,480	-	-
2006	258,475	259,070	595.4	595.4
2007	267,919	268,541	622.6	27.2
2008	265,482	266,105	622.7	0.1
2009	267,862	268,485	622.7	(0.0)
2010	263,166	263,788	622.7	0.0
		Cumulative		622.7

With regards to b) under Step 3, Table 7 show the changes referenced to the year 2010 between the COHYST 2010 land use file and the unretired acres represented in the retirement scenario land use file for the Robust Review. The table presents an annual summary for the years 2011 – 2023 of the modifications made to the number of acres irrigated only with ground water based on the 2010 acreage.

Column (A) of Table 7 presents a summary taken from the model input files of the total number of acres irrigated only with ground water represented within the NRD in the “unretired condition” of the retirement scenario. This column can be contrasted with Column (A) of Table 5 to see the total annual acreage change represented in the model between the baseline (all retirements included) condition (Table 5) and the “unretired” scenario condition (Table 7) for the years 2011 through 2023.

Column (B) of Table 7 presents the annual change made to the preceding year’s acreage total for determining a given year’s adjusted acreage value. Column (B) was calculated using the values in Columns (C) through (J).

Table 7. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2023.

Year	(A) Groundwater Only Irrigated Acres	(B) =-((G)-(I)-(J)) Difference in Groundwater only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away (Table 2)	(D) Transfers to (Table 3)	(E) Non Area Transfers Away	(F) Non Area Transfers To	(G) =(C)–(D) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Reinstated Temporary Retirements (Table 4)	(J) Rounding Residuals
2011	263,796.5	8.1	814.0	821.8			(7.8)	(7.8)	-	0.3
2012	263,775.2	(21.3)	1,631.7	1,569.5			62.2	54.4	40.8	0.1
2013	263,800.0	24.8	1,840.5	1,865.3			(24.8)	29.6	-	(0.0)
2014	263,800.0	-					-	29.6	-	-
2015	263,800.0	-					-	29.6	-	-
2016	263,800.0	-					-	29.6	-	-
2017	263,800.0	-					-	29.6	-	-
2018	263,800.0	-					-	29.6	-	-
2019	263,800.0	-					-	29.6	-	-
2020	263,800.0	-					-	29.6	-	-
2021	263,800.0	-					-	29.6	-	-
2022	263,800.0	-					-	29.6	-	-
2023	263,800.0	-					-	29.6	-	-

Tables 8 and 9 show the annual area of groundwater only irrigated land for each county in the TPNRD within the Robust Review's baseline and unretirement scenarios. Finally, Tables 10 and11 show the annual area of groundwater only irrigated land for each county in the TPNRD and Platte River Drainage basin within the Robust Review's baseline and unretirement scenarios.

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,873	8,285	140
1957	280	10,202	10,006	140
1958	237	10,809	11,681	140
1959	259	11,064	13,596	140
1960	280	12,154	13,940	140
1961	358	12,975	13,933	280
1962	365	14,036	14,258	280
1963	336	15,026	14,721	420
1964	330	15,865	14,864	420
1965	420	18,019	17,328	420
1966	399	19,825	19,369	420
1967	549	22,606	21,894	420
1968	906	24,595	23,982	700
1969	1,159	26,818	26,102	840
1970	1,400	28,644	31,203	980
1971	1,839	30,082	35,802	980
1972	1,818	31,813	40,612	980

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,873	8,285	140
1957	280	10,202	10,006	140
1958	237	10,809	11,681	140
1959	259	11,064	13,596	140
1960	280	12,154	13,940	140
1961	358	12,975	13,933	280
1962	365	14,036	14,258	280
1963	336	15,026	14,721	420
1964	330	15,865	14,864	420
1965	420	18,019	17,328	420
1966	399	19,825	19,369	420
1967	549	22,606	21,894	420
1968	906	24,595	23,982	700
1969	1,159	26,818	26,102	840
1970	1,400	28,644	31,203	980
1971	1,839	30,082	35,802	980
1972	1,818	31,813	40,612	980

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
1973	1,933	33,438	45,704	1,260
1974	2,203	35,177	50,349	1,540
1975	2,881	40,123	57,650	1,540
1976	3,068	46,074	62,725	1,540
1977	3,912	52,163	69,618	1,820
1978	5,277	57,650	76,349	2,940
1979	5,602	59,990	78,875	3,560
1980	6,470	62,452	82,621	4,158
1981	7,300	65,245	85,496	4,387
1982	7,653	67,611	88,954	4,746
1983	7,551	67,158	88,061	4,972
1984	7,670	67,173	85,653	5,350
1985	10,496	59,997	98,168	4,987
1986	10,513	60,079	97,769	5,094
1987	10,691	59,892	96,995	5,263
1988	10,714	61,442	97,483	5,323
1989	10,824	63,871	98,705	5,380
1990	10,845	65,847	99,915	5,438
1991	10,868	67,211	100,718	5,494
1992	10,906	68,534	102,556	5,573
1993	10,929	69,355	103,469	5,561
1994	11,067	71,249	104,183	5,550
1995	11,209	72,978	105,622	5,545
1996	11,461	75,348	108,418	5,541
1997	11,506	78,805	109,820	5,541
1998	11,206	79,530	111,264	5,226
1999	10,793	80,715	112,223	4,987

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
1973	1,933	33,438	45,704	1,260
1974	2,203	35,177	50,349	1,540
1975	2,881	40,123	57,650	1,540
1976	3,068	46,074	62,725	1,540
1977	3,912	52,163	69,618	1,820
1978	5,277	57,650	76,349	2,940
1979	5,602	59,990	78,875	3,560
1980	6,470	62,452	82,621	4,158
1981	7,300	65,245	85,496	4,387
1982	7,653	67,611	88,954	4,746
1983	7,551	67,158	88,061	4,972
1984	7,670	67,173	85,653	5,350
1985	10,496	59,997	98,168	4,987
1986	10,513	60,079	97,769	5,094
1987	10,691	59,892	96,995	5,263
1988	10,714	61,442	97,483	5,323
1989	10,824	63,871	98,705	5,380
1990	10,845	65,847	99,915	5,438
1991	10,868	67,211	100,718	5,494
1992	10,906	68,534	102,556	5,573
1993	10,929	69,355	103,469	5,561
1994	11,067	71,249	104,183	5,550
1995	11,209	72,978	105,622	5,545
1996	11,461	75,348	108,418	5,541
1997	11,506	78,805	109,820	5,541
1998	11,206	79,530	111,264	5,226
1999	10,793	80,715	112,223	4,987

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2000	10,471	82,230	113,406	4,826
2001	9,487	84,154	115,353	4,318
2002	9,272	86,334	121,210	5,077
2003	9,507	89,925	128,803	5,207
2004	9,732	94,959	135,478	5,339
2005	10,096	95,166	139,426	5,791
2006	10,232	95,184	147,632	5,427
2007	11,112	98,022	152,475	6,310
2008	10,687	97,668	150,789	6,339
2009	10,113	98,320	152,875	6,554
2010	9,180	97,947	150,456	5,583
2011	9,180	97,885	150,526	5,583
2012	9,180	97,901	150,436	5,583
2013	8,613	97,725	151,193	5,593
2014	8,613	97,725	151,193	5,593
2015	8,613	97,725	151,193	5,593
2016	8,613	97,725	151,193	5,593
2017	8,613	98,291	151,221	5,593
2018	8,613	98,291	151,221	5,593
2019	8,613	98,291	151,221	5,593
2020	8,613	98,291	151,221	5,593
2021	8,613	98,291	151,221	5,593
2022	8,613	98,291	151,221	5,593
2023	8,613	98,291	151,262	5,593
2024	8,613	98,291	151,262	5,593
2025	8,613	98,291	151,262	5,593
2026	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2000	10,471	82,230	113,406	4,826
2001	9,487	84,154	115,353	4,318
2002	9,272	86,334	121,210	5,077
2003	9,507	89,925	128,803	5,207
2004	9,732	94,959	135,478	5,339
2005	10,096	95,166	139,426	5,791
2006	10,232	95,779	147,632	5,427
2007	11,112	98,617	152,503	6,310
2008	10,687	98,263	150,816	6,339
2009	10,113	98,915	152,903	6,554
2010	9,180	98,543	150,483	5,583
2011	9,180	98,480	150,553	5,583
2012	9,180	98,467	150,545	5,583
2013	8,613	98,291	151,303	5,593
2014	8,613	98,291	151,303	5,593
2015	8,613	98,291	151,303	5,593
2016	8,613	98,291	151,303	5,593
2017	8,613	98,291	151,303	5,593
2018	8,613	98,291	151,303	5,593
2019	8,613	98,291	151,303	5,593
2020	8,613	98,291	151,303	5,593
2021	8,613	98,291	151,303	5,593
2022	8,613	98,291	151,303	5,593
2023	8,613	98,291	151,303	5,593
2024	8,613	98,291	151,303	5,593
2025	8,613	98,291	151,303	5,593
2026	8,613	98,291	151,303	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2027	8,613	98,291	151,262	5,593
2028	8,613	98,291	151,262	5,593
2029	8,613	98,291	151,262	5,593
2030	8,613	98,291	151,262	5,593
2031	8,613	98,291	151,262	5,593
2032	8,613	98,291	151,262	5,593
2033	8,613	98,291	151,262	5,593
2034	8,613	98,291	151,262	5,593
2035	8,613	98,291	151,262	5,593
2036	8,613	98,291	151,262	5,593
2037	8,613	98,291	151,262	5,593
2038	8,613	98,291	151,262	5,593
2039	8,613	98,291	151,262	5,593
2040	8,613	98,291	151,262	5,593
2041	8,613	98,291	151,262	5,593
2042	8,613	98,291	151,262	5,593
2043	8,613	98,291	151,262	5,593
2044	8,613	98,291	151,262	5,593
2045	8,613	98,291	151,262	5,593
2046	8,613	98,291	151,262	5,593
2047	8,613	98,291	151,262	5,593
2048	8,613	98,291	151,262	5,593
2049	8,613	98,291	151,262	5,593
2050	8,613	98,291	151,262	5,593
2051	8,613	98,291	151,262	5,593
2052	8,613	98,291	151,262	5,593
2053	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2027	8,613	98,291	151,303	5,593
2028	8,613	98,291	151,303	5,593
2029	8,613	98,291	151,303	5,593
2030	8,613	98,291	151,303	5,593
2031	8,613	98,291	151,303	5,593
2032	8,613	98,291	151,303	5,593
2033	8,613	98,291	151,303	5,593
2034	8,613	98,291	151,303	5,593
2035	8,613	98,291	151,303	5,593
2036	8,613	98,291	151,303	5,593
2037	8,613	98,291	151,303	5,593
2038	8,613	98,291	151,303	5,593
2039	8,613	98,291	151,303	5,593
2040	8,613	98,291	151,303	5,593
2041	8,613	98,291	151,303	5,593
2042	8,613	98,291	151,303	5,593
2043	8,613	98,291	151,303	5,593
2044	8,613	98,291	151,303	5,593
2045	8,613	98,291	151,303	5,593
2046	8,613	98,291	151,303	5,593
2047	8,613	98,291	151,303	5,593
2048	8,613	98,291	151,303	5,593
2049	8,613	98,291	151,303	5,593
2050	8,613	98,291	151,303	5,593
2051	8,613	98,291	151,303	5,593
2052	8,613	98,291	151,303	5,593
2053	8,613	98,291	151,303	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2054	8,613	98,291	151,262	5,593
2055	8,613	98,291	151,262	5,593
2056	8,613	98,291	151,262	5,593
2057	8,613	98,291	151,262	5,593
2058	8,613	98,291	151,262	5,593
2059	8,613	98,291	151,262	5,593
2060	8,613	98,291	151,262	5,593
2061	8,613	98,291	151,262	5,593
2062	8,613	98,291	151,262	5,593
2063	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2054	8,613	98,291	151,303	5,593
2055	8,613	98,291	151,303	5,593
2056	8,613	98,291	151,303	5,593
2057	8,613	98,291	151,303	5,593
2058	8,613	98,291	151,303	5,593
2059	8,613	98,291	151,303	5,593
2060	8,613	98,291	151,303	5,593
2061	8,613	98,291	151,303	5,593
2062	8,613	98,291	151,303	5,593
2063	8,613	98,291	151,303	5,593

*Due to the construct of the model, up to 132 groundwater acres in the TPNRD are located in cells classified as Logan County. This is caused by cell boundaries and legal boundaries not being congruent. The cell is the smallest unit of the model. Each cell was assigned a county designation by the location of the cell centroid. Even if a cell is bisected by the county boundary, the entire cell is assigned to one county. The same process was used to assign each cell an NRD designation.

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,818	8,263	140
1957	280	10,146	9,979	140
1958	237	10,757	11,654	140
1959	259	11,005	13,561	140
1960	280	12,094	13,907	140
1961	358	12,915	13,899	280
1962	365	13,965	14,224	280
1963	336	14,932	14,688	420
1964	330	15,801	14,834	420
1965	420	17,898	17,282	420
1966	399	19,714	19,328	420
1967	549	22,527	21,819	420
1968	790	24,513	23,841	700
1969	1,042	26,573	25,977	840
1970	1,165	28,357	31,009	980
1971	1,581	29,789	35,502	980
1972	1,465	31,546	40,067	980
1973	1,607	33,154	45,177	1,260
1974	1,907	34,313	49,581	1,540
1975	2,517	39,056	56,459	1,540

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,818	8,263	140
1957	280	10,146	9,979	140
1958	237	10,757	11,654	140
1959	259	11,005	13,561	140
1960	280	12,094	13,907	140
1961	358	12,915	13,899	280
1962	365	13,965	14,224	280
1963	336	14,932	14,688	420
1964	330	15,801	14,834	420
1965	420	17,898	17,282	420
1966	399	19,714	19,328	420
1967	549	22,527	21,819	420
1968	790	24,513	23,841	700
1969	1,042	26,573	25,977	840
1970	1,165	28,357	31,009	980
1971	1,581	29,789	35,502	980
1972	1,465	31,546	40,067	980
1973	1,607	33,154	45,177	1,260
1974	1,907	34,313	49,581	1,540
1975	2,517	39,056	56,459	1,540

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1976	2,648	44,393	61,489	1,540
1977	3,492	50,259	67,666	1,820
1978	4,857	55,248	73,851	2,940
1979	5,193	57,314	75,932	3,560
1980	6,067	59,598	79,123	4,158
1981	6,841	62,163	80,738	4,387
1982	7,188	64,269	82,255	4,746
1983	7,149	63,644	81,798	4,972
1984	7,267	63,585	79,110	5,350
1985	9,901	56,403	90,075	4,987
1986	9,918	56,495	89,710	5,094
1987	10,096	56,326	89,000	5,263
1988	10,118	57,462	89,449	5,323
1989	10,227	59,711	90,637	5,380
1990	10,247	61,259	91,808	5,438
1991	10,268	62,572	92,572	5,494
1992	10,305	63,804	94,330	5,573
1993	10,326	64,581	95,231	5,561
1994	10,464	66,004	95,934	5,550
1995	10,605	67,724	97,373	5,545
1996	10,857	69,868	100,180	5,541
1997	10,899	72,742	101,466	5,541
1998	10,618	73,239	102,532	5,226
1999	10,227	74,435	103,200	4,987
2000	9,934	75,965	104,291	4,826
2001	9,000	77,152	105,988	4,318

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1976	2,648	44,393	61,489	1,540
1977	3,492	50,259	67,666	1,820
1978	4,857	55,248	73,851	2,940
1979	5,193	57,314	75,932	3,560
1980	6,067	59,598	79,123	4,158
1981	6,841	62,163	80,738	4,387
1982	7,188	64,269	82,255	4,746
1983	7,149	63,644	81,798	4,972
1984	7,267	63,585	79,110	5,350
1985	9,901	56,403	90,075	4,987
1986	9,918	56,495	89,710	5,094
1987	10,096	56,326	89,000	5,263
1988	10,118	57,462	89,449	5,323
1989	10,227	59,711	90,637	5,380
1990	10,247	61,259	91,808	5,438
1991	10,268	62,572	92,572	5,494
1992	10,305	63,804	94,330	5,573
1993	10,326	64,581	95,231	5,561
1994	10,464	66,004	95,934	5,550
1995	10,605	67,724	97,373	5,545
1996	10,857	69,868	100,180	5,541
1997	10,899	72,742	101,466	5,541
1998	10,618	73,239	102,532	5,226
1999	10,227	74,435	103,200	4,987
2000	9,934	75,965	104,291	4,826
2001	9,000	77,152	105,988	4,318

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2002	8,796	79,165	111,189	5,077
2003	9,018	82,477	118,006	5,207
2004	9,232	87,078	124,383	5,339
2005	9,577	87,274	128,022	5,791
2006	9,784	86,962	134,677	5,427
2007	10,646	89,800	139,541	6,310
2008	10,296	89,452	137,752	6,339
2009	9,599	90,077	140,367	6,554
2010	8,722	89,812	137,454	5,583
2011	8,722	89,740	137,524	5,583
2012	8,722	89,756	137,434	5,583
2013	8,155	89,580	138,005	5,593
2014	8,155	89,580	138,005	5,593
2015	8,155	89,580	138,005	5,593
2016	8,155	89,580	138,005	5,593
2017	8,155	90,146	138,032	5,593
2018	8,155	90,146	138,032	5,593
2019	8,155	90,146	138,032	5,593
2020	8,155	90,146	138,032	5,593
2021	8,155	90,146	138,032	5,593
2022	8,155	90,146	138,032	5,593
2023	8,155	90,146	138,073	5,593
2024	8,155	90,146	138,073	5,593
2025	8,155	90,146	138,073	5,593
2026	8,155	90,146	138,073	5,593
2027	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2002	8,796	79,165	111,189	5,077
2003	9,018	82,477	118,006	5,207
2004	9,232	87,078	124,383	5,339
2005	9,577	87,274	128,022	5,791
2006	9,784	87,557	134,677	5,427
2007	10,646	90,395	139,568	6,310
2008	10,296	90,047	137,779	6,339
2009	9,599	90,672	140,394	6,554
2010	8,722	90,407	137,481	5,583
2011	8,722	90,335	137,551	5,583
2012	8,722	90,322	137,543	5,583
2013	8,155	90,146	138,114	5,593
2014	8,155	90,146	138,114	5,593
2015	8,155	90,146	138,114	5,593
2016	8,155	90,146	138,114	5,593
2017	8,155	90,146	138,114	5,593
2018	8,155	90,146	138,114	5,593
2019	8,155	90,146	138,114	5,593
2020	8,155	90,146	138,114	5,593
2021	8,155	90,146	138,114	5,593
2022	8,155	90,146	138,114	5,593
2023	8,155	90,146	138,114	5,593
2024	8,155	90,146	138,114	5,593
2025	8,155	90,146	138,114	5,593
2026	8,155	90,146	138,114	5,593
2027	8,155	90,146	138,114	5,593

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2028	8,155	90,146	138,073	5,593
2029	8,155	90,146	138,073	5,593
2030	8,155	90,146	138,073	5,593
2031	8,155	90,146	138,073	5,593
2032	8,155	90,146	138,073	5,593
2033	8,155	90,146	138,073	5,593
2034	8,155	90,146	138,073	5,593
2035	8,155	90,146	138,073	5,593
2036	8,155	90,146	138,073	5,593
2037	8,155	90,146	138,073	5,593
2038	8,155	90,146	138,073	5,593
2039	8,155	90,146	138,073	5,593
2040	8,155	90,146	138,073	5,593
2041	8,155	90,146	138,073	5,593
2042	8,155	90,146	138,073	5,593
2043	8,155	90,146	138,073	5,593
2044	8,155	90,146	138,073	5,593
2045	8,155	90,146	138,073	5,593
2046	8,155	90,146	138,073	5,593
2047	8,155	90,146	138,073	5,593
2048	8,155	90,146	138,073	5,593
2049	8,155	90,146	138,073	5,593
2050	8,155	90,146	138,073	5,593
2051	8,155	90,146	138,073	5,593
2052	8,155	90,146	138,073	5,593
2053	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2028	8,155	90,146	138,114	5,593
2029	8,155	90,146	138,114	5,593
2030	8,155	90,146	138,114	5,593
2031	8,155	90,146	138,114	5,593
2032	8,155	90,146	138,114	5,593
2033	8,155	90,146	138,114	5,593
2034	8,155	90,146	138,114	5,593
2035	8,155	90,146	138,114	5,593
2036	8,155	90,146	138,114	5,593
2037	8,155	90,146	138,114	5,593
2038	8,155	90,146	138,114	5,593
2039	8,155	90,146	138,114	5,593
2040	8,155	90,146	138,114	5,593
2041	8,155	90,146	138,114	5,593
2042	8,155	90,146	138,114	5,593
2043	8,155	90,146	138,114	5,593
2044	8,155	90,146	138,114	5,593
2045	8,155	90,146	138,114	5,593
2046	8,155	90,146	138,114	5,593
2047	8,155	90,146	138,114	5,593
2048	8,155	90,146	138,114	5,593
2049	8,155	90,146	138,114	5,593
2050	8,155	90,146	138,114	5,593
2051	8,155	90,146	138,114	5,593
2052	8,155	90,146	138,114	5,593
2053	8,155	90,146	138,114	5,593

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2054	8,155	90,146	138,073	5,593
2055	8,155	90,146	138,073	5,593
2056	8,155	90,146	138,073	5,593
2057	8,155	90,146	138,073	5,593
2058	8,155	90,146	138,073	5,593
2059	8,155	90,146	138,073	5,593
2060	8,155	90,146	138,073	5,593
2061	8,155	90,146	138,073	5,593
2062	8,155	90,146	138,073	5,593
2063	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2054	8,155	90,146	138,114	5,593
2055	8,155	90,146	138,114	5,593
2056	8,155	90,146	138,114	5,593
2057	8,155	90,146	138,114	5,593
2058	8,155	90,146	138,114	5,593
2059	8,155	90,146	138,114	5,593
2060	8,155	90,146	138,114	5,593
2061	8,155	90,146	138,114	5,593
2062	8,155	90,146	138,114	5,593
2063	8,155	90,146	138,114	5,593

Memorandum

To: Brandi Flyr – Central Platte NRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 11/21/2018
Subject: COHYST Area Robust Review: CPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Central Platte NRD (CPNRD).

To evaluate changes to land use within the CPNRD, TFG's primary work tasks included compiling available acreage change information; spatially processing the compiled information to ensure unique datasets; developing land use summary tables to facilitate review of the provided information; placing the acreage change transactions into the constructs of the COHYST 2010 watershed model's land use files in order to extend the baseline land use dataset through 2013; and finally to then create a new land use data set for the Robust Review's unretired scenario.

Data Collection and Spatial Processing

For the first step in the process, TFG worked with NDNR and CPNRD to gather available land use change information. Ultimately, CPNRD provided four ArcGIS® shape files and NDNR provide one ArcGIS® shape file and an Excel spreadsheet upon which the analyses for CPNRD were based. The shape files from CPNRD were named:

- *Acres_Added_2_13_2018.shp*
  - Contains spatial locations of areas where irrigation was transferred to
  - Comprised of 2,925 entries
  - 970 of those entries occurred between 2011 and 2013
- *Acres_Offset_2_13_2018.shp*
  - Contains spatial location of areas where irrigation was transferred from
  - Comprised of 3,287 entries
  - 725 of those entries occurred between 2011 and 2013
- *CPNRD_2004_CIA_2018_02_13.shp*
  - 2004 certified acreage coverage
- *WB_PURCHASES.shp*
  - Spatial location of permanent retirements initiated through CPNRD's water bank.
  - Contained 71 entries

NDNR provided the following files:

- *CREP.shp*
  - Contains spatial locations of retirements funded with either CREP or EQIP funds and tracked by NDNR

- *20180829_COHYSTAreaMissing Dates.xlsx*
  - Provided supplementary contract starting and end dates for parcels included in *CREP.shp*.

To ensure that the spatial information provided was unique and did not reflect overlapping polygons, the information was linked to the COHYST 2010 model grid. COHYST 2010 uses a grid of 160-acre sized model cells. Cells are assigned to counties, NRDs, and/or drainage basins based on the location of the cell's centroid. This results in a model cell being assigned a single value for a given feature class. For example, if the border of an NRD passes through a model cell, whichever NRD the cell's centroid is within determines which NRD the cell is assigned to within the model. For this reason, it is possible to have an activity which occurs within a cell along a feature border to be enacted by one entity that shares the border, but for the model to summarize the activity to the other entity which shares the border.

After joining the provided spatial information to the COHYST 2010 model grid, the following observations were made:

1. There were multiple overlapping parcels within the *Acres_Added_2_13_2018.shp* and *Acres_Offset_2_13_2018.shp* datasets
   a. This led to potential changes in ground water only irrigated lands greater than the number of acres within a cell
2. There were irrigated acres to be offset that did not have an underlying entry in the *CPNRD_2004_CIA_2018_02_13.shp* dataset.
3. The majority of the parcels identified in *WB_PURCHASES.shp* were also included in the *Acres_Offset_2_13_2018.shp dataset*
   a. There was one completely unique WB entry
4. The *WB_PURCHASES.shp* dataset included transactions for surface water and comingled acres as well as ground water only acres

With respect to item 1 above, to account for the overlapping parcels within the acreage transfer datasets, the shape files were dissolved by the transfer year using the software ArcGIS®. This eliminated the ability to add or remove the same acres multiple time in a single year but allowed for transfers to and from in subsequent years. The 'Union' function within ArcGIS® was used to associate the transfer and retirement shape file information to the COHYST model grid.

After discussion with CPNRD regarding item 2, the offset acreage parcels which did not have an underlying entry in the certified acreage dataset were identified and returned to CPNRD. CPNRD determined if the parcels were truly offset acres; ultimately providing TFG with their recommendations on which parcels to omit from the analysis. TFG removed these parcels from the dataset moving forward.

After additional discussions with CPNRD about item 3, it was determined that the *Acres_Offset_2_13_2018.shp* dataset included both transfers away <u>and</u> permanent retirements (which were initially believed to be contained in the *WB_PURCHASES.shp* dataset). The *WB_PURCHASES.shp* coverage was spatially queried against the *Acres_Offset_2_13_2018.shp* dataset to determine which offset transactions were retirements. The *Acres_Offset_2_13_2018.shp* dataset was then divided into two sets: offset transfers and offset retirements.

Item 4 was noted due to the Robust Review being focused on ground water only transactions. The offset acreage transactions which had a designation of surface water only or comingled were therefore removed.

Land Use Summary Tables

Using information provided by CPNRD, NDNR, and other basin NRDs, TFG compiled a final summary of the retirements, transfers, and variances occurring within the CPNRD assigned model domain. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-7 below summarize the information provided to TFG. Tables 8-14 summarize the distribution of that information into the modeling input files.

Table 1 provides an overall summary of the retirement and transfer acreage source information relevant to the CPNRD received by TFG. Columns A through E on Table 1 summarize the information provided by CPNRD and NDNR. Column F summarizes information tracked by other basin NRDs, but whose spatial location upon distribution to the model placed acreage within the model domain assigned to the CPNRD. Subsequent tables define the source(s) of this information.

Table 1. Summary of CPNRD acreage changes for implementation into the Robust Review.

Year	CPNRD Data					Non-CPNRD Data	(G) Change
	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Transfers Away	
Baseline Change	(-)	(+)	(-)	(+)	(-)	(-)	
1999	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-
2005	304.4	-	-	-	-	-	(304.4)
2006	260.7	-	150.1	-	-	-	(410.8)
2007	111.9	-	-	-	-	-	(111.9)
2008	52.2	-	-	-	-	-	(52.2)
2009	6.9	-	1,513.8	-	-	-	(1,520.7)
2010	-	-	317.8	-	-	-	(317.8)
2011	-	-	430.8	1,087.2	683.5	1.6	(28.7)
2012	-	-	211.3	4,397.8	1,021.6	3.8	3,161.1
2013	-	-	19.1	4,255.3	1,440.0	77.1	2,719.1
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	282.7	-	-	-	-	282.7
2019	-	21.5	-	-	-	-	21.5
2020	-	39.7	-	-	-	-	39.7
2021	-	196.4	-	-	-	-	196.4
2022	-	125.0	-	-	-	-	125.0
2023	-	70.8	-	-	-	-	70.8
Total	736.1	736.1	2,642.9	9,740.3	3,145.1	82.5	3,869.8

Data Source Discussion for Table 1 Columns A-B

The CREP related information provided by NDNR was the source of the temporary retirement information summarized in Column A of Table 1. The *CREP.shp* file included the most up to date list of CREP and EQIP contracts available from NDNR. TFG queried the data spatially in the shape file to obtain only the parcels located within the CPNRD. That query returned 58 polygons totaling 1,640 acres. The information was then limited to parcels irrigated only with ground water and which were initiated prior to the 2013 irrigation season. This reduced the number of acres to 876.4.

A spatial comparison of the CREP/EQIP information provided by NDNR and the permanent retirement information provided by CPNRD (via *WB_PURCHASES.shp*) revealed a small amount of overlap between the two datasets. The overlapping acres were removed from the *CREP.shp* dataset and retained in the in the CPNRD provided information; however, the date the retirements were initiated was changed to reflect the initial temporary retirement year (from 2009 to 2006). This resulted in 140.3 acres being converted from temporarily retired to permanently retired. Reducing the remaining 876.4 CREP/EQIP retirement acres by the 140.3 acres yields 736.1 acres within the CPNRD area (and an additional 0.7 acres in the TBNRD area due to the cell assignment procedures discussed earlier). Table 2 summarizes these values. Note that Column 'CPNRD' on Table 2 is the source of the information populated into Column A of Table 1.

Table 2. Summary of CPNRD CREP and EQIP temporary retirements.

Year	Total	CPNRD	TBNRD
2005	304.4	304.4	-
2006	260.7	260.7	-
2007	111.9	111.9	-
2008	52.2	52.2	-
2009	7.6	6.9	0.7
2010	-	-	-
2011	-	-	-
2012	-	-	-
2013	-	-	-
Total	736.8	736.1	0.7

Based on the contract start and end dates contained in *CREP.shp* and *20180829_COHYSTAreaMissing Dates.xlsx*, the year the temporary retirements end was computed. This information is shown on Table 3. Note that Column 'CPNRD' on Table 3 is the source of the information populated into Column B of Table 1.

Table 3. Summary of CPNRD CREP and EQIP temporary retirements reinstatements.

Year	Total	CPNRD	TBNRD
2018	282.7	282.7	-
2019	21.5	21.5	-
2020	40.4	39.7	0.7
2021	196.4	196.4	-
2022	125.0	125.0	-
2023	70.8	70.8	-
Total	736.8	736.1	0.7

Data Source Discussion for Table 1 Column C

Table 4 summarizes the permanent retirement information provided in the datasets from CPNRD. Similar to the CREP/EQIP acreage, some permanent retirements occurred in cells assigned to neighboring NRDs. Note that Column A of Table 4 is the source of the information populated into Column C of Table 1.

Table 4. Summary of CPNRD permanent retirement acreage.

Year	(A) = B + C CPNRD Retirements	(B) Water Bank Only	(C) Water Bank And Offset Acres	LLNRD	TBNRD
2006	150.1	-	150.1	-	-
2007	-	-	-	-	-
2008	-	-	-	-	-
2009	1,513.8	75.0	1,438.8	0.4	149.1
2010	317.8	-	317.8	-	-
2011	430.8	-	430.8	-	-
2012	211.3	-	211.3	-	-
2013	19.1	-	19.1	-	-
Total	2,642.9	75.0	2,567.9	0.4	149.1

Note:
LLNRD – Lower Loup Natural Resources District
TBNRD – Tri-Basin Natural Resources District
(B) represents the data found only in the WB Purchases shapefile
(C) represents the intersection of the Acres Offset data set and the WB Purchases shapefiles limited to groundwater only transactions

The 140.3 acres converted from temporary to permanent as discussed in the Section above are reflected in this table.

Data Source Discussion for Table 1 Columns D and E

Table 5 summarizes the amount of new irrigated acreage resulting from CPNRD transfers, while Table 6 summarizes the amount of irrigated acreage reduced as a result of transfers occurring in the CPNRD.

Table 5. Summary of CPNRD added acres.

Year	Total	CPNRD	UBBNRD	LBNRD	LLNRD	LPNNRD	TBNRD
2011	1,107.4	1,087.2	5.1	10.6	4.5	-	-
2012	4,455.9	4,397.8	4.4	2.5	49.4	1.8	-
2013	4,268.9	4,255.3	10.0	-	2.2	-	1.4
Total	9,832.2	9,740.3	19.5	13.1	56.1	1.8	1.4

Table 6. Summary of CPNRD offset acres.

Year	Total	CPNRD	UBBNRD	LLNRD	LPNNRD
2011	698.3	683.5	4.3	10.5	-
2012	1,037.9	1,021.6	5.3	9.2	1.8
2013	1,445.2	1,440.0	2.9	2.3	-
Total	3,181.4	3,145.1	12.5	22.0	1.8

Note for Tables 5 and 6:
UBBNRD – Upper Big Blue Natural Resources District
LBNRD – Little Blue Natural Resources District
LLNRD – Lower Loup Natural Resources District
LPNNRD – Lower Platte North Natural Resources District
TBNRD – Tri-Basin Natural Resources District

Columns 'CPNRD' in Tables 5 and 6 are the sources for the information populated into Columns D and E, respectively, of Table 1. The tables also reflect a small amount of acreage attributed to cells assigned to neighboring NRDs due to the cell assignment process previously discussed.

Data Source Discussion for Table 1 Column F

Table 7 reflects, similar to how acreage modifications tracked by the CPNRD were located within cells assigned to other NRDs within the model, a small number of transactions tracked by the TPNRD (5.4 acres) and TBNRD (77.1 acres) that were placed into model cells which were assigned to the CPNRD. These transactions were all transfers away. The information in Column 'Total' of Table 7 is the source of the information populated into Column F of Table 1.

Table 7. Acreage summary of Non-CPNRD transactions which occurred within the CPNRD assigned cells.

Year	TPNRD	TBNRD	Total
2011	1.6	-	1.6
2012	3.8	-	3.8
2013	-	77.1	77.1
Total	5.4	77.1	82.5

Spatial Analysis Method

ArcGIS® was used to link the retirement, transfer, and variance information provided by CPNRD and NDNR to the COHYST 2010 model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

NDNR and CPNRD provided retirement and transfer acreage information in the form of shape files. The parcel information within the shape files was dissolved by year to remove duplicate areas. The offset acreage information was divided between transfers away and permanent retirements. The union function within ArcGIS® was applied to each shapefile to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS®.

Step 2: Building the Baseline Land Use

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update was the 2010 land use file[1] from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of the investigation was the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all of the temporarily retired acres.

Acres were to be added or removed from their assigned cells. If there was insufficient space[2] for new acres or an insufficient amount of groundwater only acres[3] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[4]. This spatial process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom piece of FORTRAN script.

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[1] While the 'Certified Irrigated Acres' (CIA) provided by CPNRD was considered as the starting point for the land use update, it was decided to use the land use data set developed by Riverside for COHYST 2010. The CIA coverage represents the maximum potential groundwater irrigated acres. The Riverside coverage identified the groundwater only irrigated acres which were actively being irrigated in 2010.

[2] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres

[3] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres

[4] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. 'r' and 'c' indicate the row column index of the cell.

The results of step 2 are shown in Table 8. As intended, the values in Column B of Table 8 match (sans de minimis rounding resulting from the distribution process) the original source information summarized in Column G of Table 1 for the years 2011-2023. This indicates that the acreage values provided by CPNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 8 also includes the changes attributable to the CPNRD which occur in cells assigned to its neighboring NRDs. Column C represents the total impact of Table 3 (Columns: TBNRD), Table 5 (Columns: UBBNRD, LBNRD, LLNRD, LPNNRD, & TBNRD), and Table 6 (Columns UBBNRD, LLNRD, & LPNNRD). It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 8. Change in groundwater only irrigated acres within the CPNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in CPNRD	(B) Annual Change in CPNRD Groundwater Only Irrigated Acres in the CPNRD	(C) Change in CPNRD Groundwater Only Irrigated Acres not in the CPNRD
2010	896,869.5	-	-
2011	896,840.8	(28.7)	5.4
2012	900,002.3	3,161.5	41.8
2013	902,721.3	2,719.0	8.4
2014	902,721.3	-	-
2015	902,721.3	-	-
2016	902,721.3	-	-
2017	902,721.3	-	-
2018	903,004.1	282.8	-
2019	903,025.6	21.5	-
2020	903,065.3	39.7	0.7
2021	903,261.7	196.4	-
2022	903,386.7	125.0	-
2023	903,457.5	70.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

A new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired. Other key elements of the scenario include:

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retired acres were added back in 2011 and remain moving forward.

Table 9 shows the change between the COHYST 2010 land use file and the unretired retirements scenario. The difference between the two data sets shows the cumulative change over time. Again, as intended, the annual change in ground water only irrigated acres shown on Table 8 Column D match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column G of Table 1 for the years 1999 through 2010 (the sign reversal indicates removal (unretirement) of the acreage). This indicates that the acreage values provided by the CPNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 9. Change in Groundwater Only Irrigated Acres in the CPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres within the CPNRD	
Year	(A) Run029	(B) Modified Land Use	(C) Cumulative	(D) Annual
1999	828,559	828,559	(0.0)	(0.0)
2000	834,741	834,741	-	0.0
2001	843,080	843,080	-	-
2002	854,133	854,133	0.0	0.0
2003	866,690	866,690	(0.0)	(0.0)
2004	878,324	878,324	-	0.0
2005	887,953	888,258	304.4	304.4
2006	883,622	884,337	715.1	410.7
2007	914,684	915,511	826.6	111.5
2008	877,717	878,597	879.5	52.9
2009	907,031	909,431	2,400.1	1,520.6
2010	896,870	899,587	2,717.9	317.8
		Cumulative		2,717.9

Table 10 shows the changes between the COHYST 2010 land use file and the land use file developed for the "unretired" condition within the Robust Review's retirement scenario. Column A in the table presents the annual acreage irrigated only with ground water from 2011 through 2023 for the "unretired" land use data set. Column B summarizes the acreage changes made to arrive at values presented in Column A. Columns C through I present the information used in the computation of the Column B values.

SUMMARY

Tables 8 through 10 summarize the background information as to how the land use files for the Robust Review will be populated. Comparisons back to Table 1 confirm the information provided to TFG by CPNRD, NDNR and other entities referenced in the memorandum were fully included in the model input files. The retirement scenario within the Robust Review involves two land use datasets: the Baseline Set; and the Unretired Set.

For the Baseline Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column A in Table 9 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 8 will be used

For the Unretired Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column B in Table 9 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 10 will be used

Table 10. Change in Groundwater Only Irrigated Acres in the CPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2023.

Year	(A) Groundwater Only Irrigated Acres	(B) Difference in Ground Water Only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away	(D) Transfers To	(E) Non Area Transfers Away	(F) Non Area Transfers To	(G) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Residuals
2011	899,989.5	402.1	683.5	1,087.2	1.6		(402.1)	(402.1)	(0.0)
2012	903,362.3	3,372.8	1,021.6	4,397.8	3.8		(3,372.4)	(3,774.5)	0.4
2013	906,100.4	2,738.1	1,440.0	4,255.3	77.1		(2,738.2)	(6,512.7)	(0.1)
2014	906,100.4	-					-	(6,512.7)	-
2015	906,100.4	-					-	(6,512.7)	-
2016	906,100.4	-					-	(6,512.7)	-
2017	906,100.4	-					-	(6,512.7)	-
2018	906,100.4	-					-	(6,512.7)	-
2019	906,100.4	-					-	(6,512.7)	-
2020	906,100.4	-					-	(6,512.7)	-
2021	906,100.4	-					-	(6,512.7)	-
2022	906,100.4	-					-	(6,512.7)	-
2023	906,100.4	-					-	(6,512.7)	-

Tables 11 and 12 show the annual area of groundwater only irrigated land for each county in the CPNRD within the Robust Review baseline and unretirement scenarios. Finally, Tables 13 and 14 show the annual area of groundwater only irrigated land for each county in the CPNRD and Platte River Drainage basin within the Robust Review's baseline and unretirement scenarios.

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	38,694	883	253	20,701	168	128	2,030
1951	38,107	596	26,837	-	40,090	897	220	18,343	170	118	1,864
1952	38,472	459	26,426	-	41,482	904	185	15,963	165	106	1,703
1953	38,638	665	26,443	-	42,875	781	120	13,606	160	84	1,541
1954	38,818	773	27,725	-	44,267	616	86	11,236	155	81	1,175
1955	42,204	1,217	35,398	58	51,750	915	233	16,096	202	143	2,394
1956	45,745	1,496	43,244	169	59,229	1,346	394	20,960	302	225	3,174
1957	49,510	1,920	50,498	281	66,706	2,042	554	25,719	402	308	3,861
1958	53,516	2,174	56,649	320	74,185	2,510	727	30,563	488	399	4,869
1959	57,358	2,538	64,005	467	81,662	2,990	891	35,406	552	463	5,867
1960	58,532	2,713	64,363	539	84,161	3,249	1,104	39,426	738	571	7,673
1961	59,699	2,720	64,418	743	86,660	3,536	1,307	43,459	922	697	9,349
1962	60,893	2,832	64,716	736	89,163	3,816	1,551	47,494	1,084	811	11,036
1963	62,188	2,897	65,266	757	91,656	4,062	1,823	51,508	1,218	960	12,692
1964	63,155	2,999	65,219	692	94,156	4,388	2,070	55,499	1,394	1,037	14,087
1965	67,131	4,116	67,466	1,321	98,490	4,867	3,070	60,697	1,750	1,245	16,472
1966	71,398	5,058	69,448	1,622	102,777	5,283	4,020	65,832	2,070	1,457	19,161
1967	75,375	5,991	71,862	1,604	107,112	5,667	4,808	70,912	2,482	1,747	21,573
1968	79,317	6,844	74,296	1,882	111,447	6,017	5,605	75,955	2,817	2,023	23,798
1969	83,508	7,897	76,595	1,952	115,722	6,698	6,275	80,999	3,128	2,247	26,254
1970	88,978	8,703	86,595	2,361	122,556	7,308	6,529	85,769	3,245	2,435	27,857
1971	94,430	9,677	96,852	2,716	129,273	7,958	7,032	90,528	3,276	2,591	29,419
1972	99,125	10,412	107,389	2,779	136,031	8,434	7,235	95,280	3,461	2,692	30,849
1973	104,220	11,069	117,907	3,115	142,807	8,882	7,548	99,922	3,715	2,769	32,414
1974	109,536	11,863	129,601	3,299	149,581	9,553	8,112	104,690	4,163	2,883	34,222
1975	116,243	12,546	132,081	3,729	156,915	10,270	8,995	111,897	4,829	3,245	36,893
1976	122,587	13,248	132,581	3,880	164,283	11,296	9,733	118,796	5,188	3,529	39,541
1977	129,105	14,362	135,105	4,265	171,636	11,780	10,114	125,820	5,644	3,975	42,361

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1978	136,078	15,494	136,151	4,481	178,967	12,647	10,967	132,888	6,213	4,204	44,679
1979	138,896	16,663	140,172	4,258	180,519	12,768	11,283	134,209	6,188	4,171	43,948
1980	142,065	17,443	145,645	4,369	182,018	12,827	11,613	135,467	6,268	4,117	42,961
1981	146,078	18,135	150,431	4,153	183,565	12,864	11,917	136,665	6,223	4,290	42,138
1982	149,224	18,722	155,109	4,352	184,999	12,810	12,157	137,922	6,293	4,277	41,025
1983	146,691	18,607	152,394	4,299	181,499	12,558	11,695	135,549	6,363	4,338	41,255
1984	143,647	17,959	149,510	4,114	177,862	12,243	11,303	133,139	6,457	4,412	41,345
1985	144,075	20,445	169,085	4,968	193,563	10,446	13,046	166,376	9,633	5,195	35,947
1986	144,745	20,080	166,815	4,908	193,519	10,344	12,745	166,499	9,564	5,214	36,157
1987	145,080	19,556	163,289	4,806	193,173	10,167	12,162	166,554	9,521	5,265	36,535
1988	146,473	19,684	163,270	4,856	194,271	10,219	12,616	167,318	9,446	5,278	36,357
1989	148,972	19,834	163,121	4,799	196,204	10,366	13,056	168,747	9,464	5,271	36,223
1990	150,649	20,009	163,019	4,738	197,294	10,424	13,501	170,202	9,556	5,280	36,063
1991	152,280	20,234	162,930	4,677	198,631	10,575	13,924	171,093	9,479	5,314	35,917
1992	154,498	20,827	163,529	4,657	200,312	10,817	14,723	172,140	9,447	5,388	35,536
1993	155,474	20,929	163,200	4,622	200,857	10,898	14,949	172,900	9,478	5,442	37,142
1994	156,701	21,061	162,887	4,588	201,279	10,984	15,203	173,400	9,534	5,495	38,749
1995	157,797	21,224	162,749	4,556	201,806	11,078	15,406	173,634	9,612	5,552	40,378
1996	159,570	21,437	163,209	4,545	203,009	11,177	15,653	174,129	9,791	5,615	42,052
1997	161,837	21,763	163,006	4,525	203,597	11,383	15,991	174,679	10,061	5,735	45,241
1998	162,219	21,787	167,423	4,818	203,667	11,425	16,038	174,203	10,129	5,900	45,809
1999	162,685	21,745	171,542	5,087	203,704	11,578	16,043	173,630	10,146	6,015	46,385
2000	163,257	21,718	175,831	5,334	204,223	11,686	16,186	173,201	10,178	6,203	46,924
2001	162,813	21,556	183,747	5,915	204,341	11,663	16,476	172,389	10,331	6,343	47,507
2002	164,295	22,660	186,859	6,214	205,180	11,707	16,511	174,074	10,446	6,470	49,718
2003	165,455	25,163	191,481	6,250	206,046	11,772	17,140	174,294	10,686	6,632	51,769
2004	166,787	26,266	195,741	6,499	207,343	11,986	17,765	174,759	10,936	6,664	53,578
2005	167,084	27,724	200,234	6,497	207,622	12,185	18,098	174,951	11,189	6,695	55,675

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2006	165,041	21,503	200,516	5,741	210,252	12,325	18,183	175,802	11,521	6,727	56,011
2007	171,270	26,613	211,532	6,538	213,805	12,740	19,019	177,883	12,213	6,862	56,209
2008	163,245	25,823	203,209	5,725	204,290	12,239	17,559	173,374	10,627	6,568	55,060
2009	170,387	27,559	211,181	6,394	208,849	12,622	18,390	176,557	11,693	6,801	56,597
2010	169,215	26,607	203,177	6,555	210,204	12,577	18,557	177,058	10,960	6,534	55,426
2011	169,132	26,591	202,848	6,551	210,356	12,714	18,650	177,059	10,978	6,534	55,427
2012	169,260	26,553	202,671	6,548	211,511	12,883	18,681	178,350	11,007	6,562	55,978
2013	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2014	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2015	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2016	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2017	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2018	169,508	26,552	202,910	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2019	169,508	26,552	202,931	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2020	169,508	26,552	202,971	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2021	169,508	26,552	203,167	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2022	169,508	26,552	203,292	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2023	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2024	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2025	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2026	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2027	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2028	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2029	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2030	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2031	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2032	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2033	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2034	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2035	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2036	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2037	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2038	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2039	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2040	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2041	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2042	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2043	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2044	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2045	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2046	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2047	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2048	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2049	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2050	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2051	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2052	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2053	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2054	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2055	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2056	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2057	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2058	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2059	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2060	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2061	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2062	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2063	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	38,694	883	253	20,701	168	128	2,030
1951	38,107	596	26,837	-	40,090	897	220	18,343	170	118	1,864
1952	38,472	459	26,426	-	41,482	904	185	15,963	165	106	1,703
1953	38,638	665	26,443	-	42,875	781	120	13,606	160	84	1,541
1954	38,818	773	27,725	-	44,267	616	86	11,236	155	81	1,175
1955	42,204	1,217	35,398	58	51,750	915	233	16,096	202	143	2,394
1956	45,745	1,496	43,244	169	59,229	1,346	394	20,960	302	225	3,174
1957	49,510	1,920	50,498	281	66,706	2,042	554	25,719	402	308	3,861
1958	53,516	2,174	56,649	320	74,185	2,510	727	30,563	488	399	4,869
1959	57,358	2,538	64,005	467	81,662	2,990	891	35,406	552	463	5,867
1960	58,532	2,713	64,363	539	84,161	3,249	1,104	39,426	738	571	7,673
1961	59,699	2,720	64,418	743	86,660	3,536	1,307	43,459	922	697	9,349
1962	60,893	2,832	64,716	736	89,163	3,816	1,551	47,494	1,084	811	11,036
1963	62,188	2,897	65,266	757	91,656	4,062	1,823	51,508	1,218	960	12,692
1964	63,155	2,999	65,219	692	94,156	4,388	2,070	55,499	1,394	1,037	14,087
1965	67,131	4,116	67,466	1,321	98,490	4,867	3,070	60,697	1,750	1,245	16,472
1966	71,398	5,058	69,448	1,622	102,777	5,283	4,020	65,832	2,070	1,457	19,161
1967	75,375	5,991	71,862	1,604	107,112	5,667	4,808	70,912	2,482	1,747	21,573
1968	79,317	6,844	74,296	1,882	111,447	6,017	5,605	75,955	2,817	2,023	23,798
1969	83,508	7,897	76,595	1,952	115,722	6,698	6,275	80,999	3,128	2,247	26,254

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1970	88,978	8,703	86,595	2,361	122,556	7,308	6,529	85,769	3,245	2,435	27,857
1971	94,430	9,677	96,852	2,716	129,273	7,958	7,032	90,528	3,276	2,591	29,419
1972	99,125	10,412	107,389	2,779	136,031	8,434	7,235	95,280	3,461	2,692	30,849
1973	104,220	11,069	117,907	3,115	142,807	8,882	7,548	99,922	3,715	2,769	32,414
1974	109,536	11,863	129,601	3,299	149,581	9,553	8,112	104,690	4,163	2,883	34,222
1975	116,243	12,546	132,081	3,729	156,915	10,270	8,995	111,897	4,829	3,245	36,893
1976	122,587	13,248	132,581	3,880	164,283	11,296	9,733	118,796	5,188	3,529	39,541
1977	129,105	14,362	135,105	4,265	171,636	11,780	10,114	125,820	5,644	3,975	42,361
1978	136,078	15,494	136,151	4,481	178,967	12,647	10,967	132,888	6,213	4,204	44,679
1979	138,896	16,663	140,172	4,258	180,519	12,768	11,283	134,209	6,188	4,171	43,948
1980	142,065	17,443	145,645	4,369	182,018	12,827	11,613	135,467	6,268	4,117	42,961
1981	146,078	18,135	150,431	4,153	183,565	12,864	11,917	136,665	6,223	4,290	42,138
1982	149,224	18,722	155,109	4,352	184,999	12,810	12,157	137,922	6,293	4,277	41,025
1983	146,691	18,607	152,394	4,299	181,499	12,558	11,695	135,549	6,363	4,338	41,255
1984	143,647	17,959	149,510	4,114	177,862	12,243	11,303	133,139	6,457	4,412	41,345
1985	144,075	20,445	169,085	4,968	193,563	10,446	13,046	166,376	9,633	5,195	35,947
1986	144,745	20,080	166,815	4,908	193,519	10,344	12,745	166,499	9,564	5,214	36,157
1987	145,080	19,556	163,289	4,806	193,173	10,167	12,162	166,554	9,521	5,265	36,535
1988	146,473	19,684	163,270	4,856	194,271	10,219	12,616	167,318	9,446	5,278	36,357
1989	148,972	19,834	163,121	4,799	196,204	10,366	13,056	168,747	9,464	5,271	36,223
1990	150,649	20,009	163,019	4,738	197,294	10,424	13,501	170,202	9,556	5,280	36,063
1991	152,280	20,234	162,930	4,677	198,631	10,575	13,924	171,093	9,479	5,314	35,917
1992	154,498	20,827	163,529	4,657	200,312	10,817	14,723	172,140	9,447	5,388	35,536
1993	155,474	20,929	163,200	4,622	200,857	10,898	14,949	172,900	9,478	5,442	37,142
1994	156,701	21,061	162,887	4,588	201,279	10,984	15,203	173,400	9,534	5,495	38,749
1995	157,797	21,224	162,749	4,556	201,806	11,078	15,406	173,634	9,612	5,552	40,378
1996	159,570	21,437	163,209	4,545	203,009	11,177	15,653	174,129	9,791	5,615	42,052
1997	161,837	21,763	163,006	4,525	203,597	11,383	15,991	174,679	10,061	5,735	45,241

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1998	162,219	21,787	167,423	4,818	203,667	11,425	16,038	174,203	10,129	5,900	45,809
1999	162,685	21,745	171,542	5,087	203,704	11,578	16,043	173,630	10,146	6,015	46,385
2000	163,257	21,718	175,831	5,334	204,223	11,686	16,186	173,201	10,178	6,203	46,924
2001	162,813	21,556	183,747	5,915	204,341	11,663	16,476	172,389	10,331	6,343	47,507
2002	164,295	22,660	186,859	6,214	205,180	11,707	16,511	174,074	10,446	6,470	49,718
2003	165,455	25,163	191,481	6,250	206,046	11,772	17,140	174,294	10,686	6,632	51,769
2004	166,787	26,266	195,741	6,499	207,343	11,986	17,765	174,759	10,936	6,664	53,578
2005	167,084	27,724	200,538	6,497	207,622	12,185	18,098	174,951	11,189	6,695	55,675
2006	165,051	21,503	201,221	5,741	210,252	12,325	18,183	175,802	11,521	6,727	56,011
2007	171,281	26,613	212,348	6,538	213,805	12,740	19,019	177,883	12,213	6,862	56,209
2008	163,255	25,823	204,078	5,725	204,290	12,239	17,559	173,374	10,627	6,568	55,060
2009	170,742	27,559	213,010	6,394	209,065	12,622	18,390	176,557	11,693	6,801	56,597
2010	169,571	26,607	205,256	6,555	210,432	12,577	18,557	177,113	10,960	6,534	55,426
2011	169,536	26,597	205,255	6,551	210,633	12,714	18,650	177,114	10,978	6,534	55,427
2012	169,707	26,559	205,247	6,548	211,787	12,883	18,681	178,405	11,007	6,562	55,978
2013	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2014	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2015	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2016	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2017	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2018	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2019	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2020	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2021	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2022	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2023	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2024	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2025	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2026	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2027	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2028	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2029	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2030	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2031	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2032	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2033	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2034	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2035	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2036	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2037	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2038	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2039	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2040	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2041	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2042	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2043	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2044	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2045	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2046	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2047	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2048	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2049	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2050	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2051	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2052	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2053	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2054	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2055	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2056	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2057	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2058	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2059	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2060	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2061	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2062	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2063	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	37,736	883	253	20,580	147	128	1,993
1951	38,107	596	26,837	-	38,967	897	220	18,220	151	118	1,798
1952	38,427	459	26,426	-	40,282	848	185	15,861	147	106	1,643
1953	38,597	665	26,443	-	41,454	732	120	13,497	142	84	1,492
1954	38,666	773	27,722	-	42,551	581	86	11,113	141	81	1,130
1955	41,954	1,217	35,370	58	49,528	801	233	15,930	171	143	2,320
1956	45,461	1,496	43,159	169	56,170	1,009	394	20,720	269	225	3,061
1957	49,047	1,920	50,373	281	62,398	1,414	537	25,320	332	308	3,654
1958	53,017	2,174	56,490	320	69,341	1,734	684	30,108	402	399	4,614
1959	56,831	2,538	63,779	467	76,263	2,064	839	34,889	461	463	5,564
1960	58,002	2,713	64,133	539	78,417	2,243	1,042	38,829	618	571	7,274
1961	59,070	2,720	64,176	743	80,640	2,437	1,231	42,804	777	697	8,867

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1962	60,251	2,832	64,471	736	82,921	2,627	1,464	46,798	924	811	10,471
1963	61,508	2,897	65,015	757	85,219	2,794	1,726	50,688	1,055	960	12,021
1964	62,477	2,999	64,950	692	87,092	3,013	1,967	54,585	1,186	1,037	13,377
1965	66,237	4,116	67,193	1,321	90,683	3,336	2,934	59,623	1,479	1,245	15,514
1966	70,468	5,058	69,130	1,622	94,197	3,589	3,854	64,682	1,746	1,457	17,938
1967	74,334	5,991	71,527	1,604	97,700	3,941	4,620	69,571	2,128	1,747	20,017
1968	78,123	6,844	73,929	1,882	101,499	4,196	5,374	74,403	2,344	2,023	22,083
1969	82,200	7,897	76,229	1,952	105,122	4,571	6,004	79,254	2,629	2,247	24,402
1970	87,492	8,703	86,185	2,361	111,092	5,086	6,264	83,830	2,763	2,435	25,756
1971	92,693	9,677	96,303	2,716	116,659	5,494	6,653	88,377	2,817	2,591	27,204
1972	97,300	10,303	106,747	2,779	122,400	5,927	6,868	92,665	2,997	2,692	28,564
1973	102,091	10,972	117,177	3,115	128,025	6,208	7,180	97,095	3,239	2,769	29,910
1974	107,137	11,682	128,835	3,299	134,016	6,529	7,745	101,782	3,701	2,883	31,597
1975	113,477	12,343	131,307	3,729	140,112	7,102	8,629	108,551	4,351	3,245	33,686
1976	119,342	13,080	131,715	3,880	145,777	7,761	9,305	115,018	4,703	3,529	36,078
1977	125,234	14,189	134,265	4,265	151,367	8,165	9,700	121,795	5,013	3,975	38,676
1978	131,712	15,294	135,229	4,481	157,612	8,790	10,515	128,568	5,552	4,204	40,768
1979	134,109	16,383	139,184	4,258	158,836	8,821	10,721	129,758	5,521	4,118	40,194
1980	136,916	17,154	144,644	4,369	160,116	8,885	11,049	130,886	5,535	4,072	39,334
1981	140,740	17,830	149,214	4,153	161,744	8,916	11,280	132,063	5,515	4,060	38,683
1982	143,696	18,401	153,794	4,352	162,727	8,875	11,506	133,142	5,602	4,049	37,629
1983	141,431	18,283	151,087	4,299	160,240	8,682	11,062	130,910	5,657	4,100	37,832
1984	138,674	17,680	148,292	4,114	157,198	8,518	10,718	128,660	5,748	4,180	37,916
1985	136,892	20,044	167,652	4,968	164,849	7,076	12,491	159,367	8,353	4,601	32,525
1986	137,539	19,686	165,401	4,908	164,844	7,009	12,207	159,463	8,300	4,618	32,716
1987	137,860	19,173	161,908	4,806	164,424	6,891	11,651	159,519	8,269	4,663	33,058
1988	139,189	19,298	161,898	4,856	165,411	6,922	12,088	160,269	8,208	4,649	32,902

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1989	141,513	19,445	161,755	4,799	166,906	7,086	12,511	161,685	8,244	4,643	32,802
1990	143,133	19,617	161,661	4,738	167,819	7,123	12,947	162,973	8,355	4,653	32,667
1991	144,709	19,839	161,577	4,677	168,815	7,142	13,356	163,767	8,293	4,646	32,489
1992	146,861	20,421	162,174	4,657	170,202	7,228	14,126	164,798	8,275	4,614	32,151
1993	147,684	20,520	161,850	4,622	170,367	7,279	14,342	165,307	8,303	4,660	33,606
1994	148,773	20,652	161,543	4,588	170,656	7,333	14,596	165,575	8,352	4,705	35,069
1995	149,833	20,813	161,411	4,556	171,142	7,392	14,799	165,806	8,419	4,755	36,563
1996	151,466	21,029	161,880	4,545	172,077	7,454	15,043	166,300	8,594	4,809	38,025
1997	153,438	21,351	161,687	4,525	172,431	7,594	15,376	166,805	8,835	4,911	40,738
1998	153,705	21,350	166,075	4,818	172,379	7,688	15,424	166,293	8,909	5,024	41,170
1999	153,876	21,310	170,164	5,087	172,366	7,796	15,435	165,758	8,923	5,121	41,716
2000	154,472	21,287	174,425	5,334	172,745	7,855	15,322	165,360	8,952	5,298	42,152
2001	154,078	21,135	182,288	5,915	172,816	7,842	15,601	164,534	9,087	5,416	42,703
2002	155,328	22,224	185,387	6,214	173,663	7,867	15,643	166,170	9,211	5,535	44,593
2003	156,124	24,687	189,865	6,250	174,370	7,913	16,280	166,310	9,426	5,563	46,421
2004	156,962	25,772	194,100	6,499	175,299	8,107	16,838	166,791	9,655	5,590	48,099
2005	157,177	26,801	198,563	6,497	175,586	8,276	17,153	166,989	9,879	5,615	49,947
2006	154,900	20,584	199,009	5,741	178,511	7,959	17,187	166,481	10,006	5,660	49,706
2007	160,930	25,670	209,739	6,538	181,168	8,353	18,012	168,783	10,608	5,795	49,821
2008	153,153	24,885	201,452	5,725	174,109	8,007	16,653	164,037	9,180	5,501	48,657
2009	160,080	26,603	209,434	6,394	176,127	8,264	17,444	167,098	10,120	5,734	50,122
2010	158,798	25,652	201,420	6,555	177,806	8,207	17,572	167,891	9,470	5,467	49,036
2011	158,711	25,636	201,095	6,551	177,827	8,226	17,663	167,880	9,488	5,467	49,037
2012	158,839	25,598	200,918	6,548	178,849	8,366	17,694	169,017	9,517	5,494	49,507
2013	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2014	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2015	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2016	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2017	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2018	158,977	25,597	201,154	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2019	158,977	25,597	201,175	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2020	158,977	25,597	201,215	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2021	158,977	25,597	201,411	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2022	158,977	25,597	201,536	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2023	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2024	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2025	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2026	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2027	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2028	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2029	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2030	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2031	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2032	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2033	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2034	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2035	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2036	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2037	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2038	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2039	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2040	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2041	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2042	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2043	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2044	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2045	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2046	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2047	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2048	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2049	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2050	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2051	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2052	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2053	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2054	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2055	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2056	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2057	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2058	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2059	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2060	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2061	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2062	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2063	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	37,736	883	253	20,580	147	128	1,993
1951	38,107	596	26,837	-	38,967	897	220	18,220	151	118	1,798
1952	38,427	459	26,426	-	40,282	848	185	15,861	147	106	1,643
1953	38,597	665	26,443	-	41,454	732	120	13,497	142	84	1,492
1954	38,666	773	27,722	-	42,551	581	86	11,113	141	81	1,130
1955	41,954	1,217	35,370	58	49,528	801	233	15,930	171	143	2,320
1956	45,461	1,496	43,159	169	56,170	1,009	394	20,720	269	225	3,061
1957	49,047	1,920	50,373	281	62,398	1,414	537	25,320	332	308	3,654
1958	53,017	2,174	56,490	320	69,341	1,734	684	30,108	402	399	4,614
1959	56,831	2,538	63,779	467	76,263	2,064	839	34,889	461	463	5,564
1960	58,002	2,713	64,133	539	78,417	2,243	1,042	38,829	618	571	7,274
1961	59,070	2,720	64,176	743	80,640	2,437	1,231	42,804	777	697	8,867
1962	60,251	2,832	64,471	736	82,921	2,627	1,464	46,798	924	811	10,471
1963	61,508	2,897	65,015	757	85,219	2,794	1,726	50,688	1,055	960	12,021
1964	62,477	2,999	64,950	692	87,092	3,013	1,967	54,585	1,186	1,037	13,377
1965	66,237	4,116	67,193	1,321	90,683	3,336	2,934	59,623	1,479	1,245	15,514
1966	70,468	5,058	69,130	1,622	94,197	3,589	3,854	64,682	1,746	1,457	17,938
1967	74,334	5,991	71,527	1,604	97,700	3,941	4,620	69,571	2,128	1,747	20,017
1968	78,123	6,844	73,929	1,882	101,499	4,196	5,374	74,403	2,344	2,023	22,083
1969	82,200	7,897	76,229	1,952	105,122	4,571	6,004	79,254	2,629	2,247	24,402
1970	87,492	8,703	86,185	2,361	111,092	5,086	6,264	83,830	2,763	2,435	25,756
1971	92,693	9,677	96,303	2,716	116,659	5,494	6,653	88,377	2,817	2,591	27,204
1972	97,300	10,303	106,747	2,779	122,400	5,927	6,868	92,665	2,997	2,692	28,564
1973	102,091	10,972	117,177	3,115	128,025	6,208	7,180	97,095	3,239	2,769	29,910
1974	107,137	11,682	128,835	3,299	134,016	6,529	7,745	101,782	3,701	2,883	31,597
1975	113,477	12,343	131,307	3,729	140,112	7,102	8,629	108,551	4,351	3,245	33,686
1976	119,342	13,080	131,715	3,880	145,777	7,761	9,305	115,018	4,703	3,529	36,078

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1977	125,234	14,189	134,265	4,265	151,367	8,165	9,700	121,795	5,013	3,975	38,676
1978	131,712	15,294	135,229	4,481	157,612	8,790	10,515	128,568	5,552	4,204	40,768
1979	134,109	16,383	139,184	4,258	158,836	8,821	10,721	129,758	5,521	4,118	40,194
1980	136,916	17,154	144,644	4,369	160,116	8,885	11,049	130,886	5,535	4,072	39,334
1981	140,740	17,830	149,214	4,153	161,744	8,916	11,280	132,063	5,515	4,060	38,683
1982	143,696	18,401	153,794	4,352	162,727	8,875	11,506	133,142	5,602	4,049	37,629
1983	141,431	18,283	151,087	4,299	160,240	8,682	11,062	130,910	5,657	4,100	37,832
1984	138,674	17,680	148,292	4,114	157,198	8,518	10,718	128,660	5,748	4,180	37,916
1985	136,892	20,044	167,652	4,968	164,849	7,076	12,491	159,367	8,353	4,601	32,525
1986	137,539	19,686	165,401	4,908	164,844	7,009	12,207	159,463	8,300	4,618	32,716
1987	137,860	19,173	161,908	4,806	164,424	6,891	11,651	159,519	8,269	4,663	33,058
1988	139,189	19,298	161,898	4,856	165,411	6,922	12,088	160,269	8,208	4,649	32,902
1989	141,513	19,445	161,755	4,799	166,906	7,086	12,511	161,685	8,244	4,643	32,802
1990	143,133	19,617	161,661	4,738	167,819	7,123	12,947	162,973	8,355	4,653	32,667
1991	144,709	19,839	161,577	4,677	168,815	7,142	13,356	163,767	8,293	4,646	32,489
1992	146,861	20,421	162,174	4,657	170,202	7,228	14,126	164,798	8,275	4,614	32,151
1993	147,684	20,520	161,850	4,622	170,367	7,279	14,342	165,307	8,303	4,660	33,606
1994	148,773	20,652	161,543	4,588	170,656	7,333	14,596	165,575	8,352	4,705	35,069
1995	149,833	20,813	161,411	4,556	171,142	7,392	14,799	165,806	8,419	4,755	36,563
1996	151,466	21,029	161,880	4,545	172,077	7,454	15,043	166,300	8,594	4,809	38,025
1997	153,438	21,351	161,687	4,525	172,431	7,594	15,376	166,805	8,835	4,911	40,738
1998	153,705	21,350	166,075	4,818	172,379	7,688	15,424	166,293	8,909	5,024	41,170
1999	153,876	21,310	170,164	5,087	172,366	7,796	15,435	165,758	8,923	5,121	41,716
2000	154,472	21,287	174,425	5,334	172,745	7,855	15,322	165,360	8,952	5,298	42,152
2001	154,078	21,135	182,288	5,915	172,816	7,842	15,601	164,534	9,087	5,416	42,703
2002	155,328	22,224	185,387	6,214	173,663	7,867	15,643	166,170	9,211	5,535	44,593
2003	156,124	24,687	189,865	6,250	174,370	7,913	16,280	166,310	9,426	5,563	46,421

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2004	156,962	25,772	194,100	6,499	175,299	8,107	16,838	166,791	9,655	5,590	48,099
2005	157,177	26,801	198,867	6,497	175,586	8,276	17,153	166,989	9,879	5,615	49,947
2006	154,910	20,584	199,713	5,741	178,511	7,959	17,187	166,481	10,006	5,660	49,706
2007	160,941	25,670	210,555	6,538	181,168	8,353	18,012	168,783	10,608	5,795	49,821
2008	153,163	24,885	202,321	5,725	174,109	8,007	16,653	164,037	9,180	5,501	48,657
2009	160,434	26,603	211,264	6,394	176,315	8,264	17,444	167,098	10,120	5,734	50,122
2010	159,154	25,652	203,499	6,555	178,006	8,207	17,572	167,946	9,470	5,467	49,036
2011	159,116	25,642	203,502	6,551	178,075	8,226	17,663	167,935	9,488	5,467	49,037
2012	159,286	25,604	203,493	6,548	179,097	8,366	17,694	169,072	9,517	5,494	49,507
2013	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2014	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2015	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2016	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2017	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2018	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2019	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2020	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2021	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2022	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2023	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2024	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2025	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2026	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2027	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2028	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2029	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2030	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2031	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2032	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2033	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2034	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2035	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2036	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2037	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2038	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2039	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2040	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2041	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2042	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2043	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2044	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2045	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2046	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2047	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2048	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2049	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2050	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2051	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2052	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2053	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2054	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2055	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2056	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2057	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2058	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2059	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2060	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2061	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2062	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2063	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Memorandum

To: John Thorburn – Tri-Basin NRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 11/21/2018
Subject: COHYST Area Robust Review: TBNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (MPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Tri-Basin NRD (TBNRD).

To account for transfers, retirements, and variances within TBNRD, TFG's primary work tasks included evaluating and summarizing the available datasets related to transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013; and to then create a new land use data set for the unretired acreage scenario. For the first step in the process, TFG worked with NDNR and TBNRD to gather the land use data (retirements, transfers, and variances) and place it into summary tables by land use type. TFG's next steps were to perform geospatial analyses using ArcGIS to identify the location of each transaction. The geospatial analysis included a proximity function in the form of a custom Fortran program to determine the closest available model cells capable of accommodating the specified land use change.

This memorandum presents a series of tables which summarize the annual number of acres retired or transferred within the TBNRD, outlines the spatial analysis methodology, and ultimately summarizes the resultant land use files.

Land Use Summary Tables

Using information provided by TBNRD, NDNR, and other basin NRDs, TFG compiled a final summary of the retirements, transfers, and variances occurring within the TPNRD assigned model domain. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-10 below summarize the information provided to TFG. Tables 11-20 summarize the distribution of that information into the modeling input files.

Table 1 provides an overall summary of the retirement and transfer acreage source information relevant to the TBNRD received by TFG. Columns A through E on Table 1 summarize the information provided by TBNRD and NDNR. Columns F through I summarize information tracked by other basin NRDs, but whose spatial location upon distribution to the model placed acreage within the model domain assigned to the TBNRD. Subsequent tables will define the source(s) of this information.

Table 1. Summary of TBNRD acreage changes for implementation into the Robust Review.

Year	TBNRD Data					Non-TBNRD Data				
	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Temporary Retirements	(G) Reinstated Temporary Retirements	(H) Permanent Retirements	(I) Transfers To	(J) Change
Baseline Change	(-)	(+)	(-)	(+)	(-)	(-)	(+)	(-)	(+)	
1999	1.9	-	-	-	-	-	-	-	-	(1.9)
2000	293.6	-	-	-	-	-	-	-	-	(293.6)
2001	408.6	-	-	-	-	-	-	-	-	(408.6)
2002	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-
2004	77.5	-	-	-	-	-	-	-	-	(77.5)
2005	259.4	7.0	-	-	-	-	-	-	-	(252.4)
2006	163.9	-	-	-	-	-	-	-	-	(163.9)
2007	219.8	-	-	-	-	-	-	-	-	(219.8)
2008	697.8	77.5	73.1	-	-	-	-	-	-	(693.4)
2009	167.9	223.7	-	-	-	0.7	-	149.1	-	(94.0)
2010	127.3	423.6	-	-	-	-	-	-	-	296.3
2011	111.3	610.3	-	178.7	246.7	-	-	-	-	431.0
2012	-	427.5	-	118.3	118.3	-	-	-	-	427.5
2013	-	450.4	-	229.4	168.5	-	-	-	1.4	512.7
2014	-	142.1	-	-	-	-	-	-	-	142.1
2015	-	127.9	-	-	-	-	-	-	-	127.9
2016	-	-	-	-	-	-	-	-	-	-
2017	-	39.0	-	-	-	-	-	-	-	39.0
2018	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-	-	-

Table 1. Summary of TBNRD acreage changes for implementation into the Robust Review.

Year	TBNRD Data					Non-TBNRD Data				
	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Temporary Retirements	(G) Reinstated Temporary Retirements	(H) Permanent Retirements	(I) Transfers To	(J) Change
2021	-	-	-	-	-	-	0.7	-	-	0.7
2022	-	-	-	-	-	-	-	-	-	-
2023	-	-	-	-	-	-	-	-	-	-
Total	2,529.0	2,529.0	73.1	526.4	533.5	0.7	0.7	149.1	1.4	(227.9)

Data Source Discussion for Table 1 Columns A through C

The TBNRD provided several spreadsheets containing information which were used to populate Table 1. Ultimately, two spreadsheets provided by the TBNRD on 7/17/2017 to TFG served as the TBNRD source information for the table:

TBNRD AppendixI_Conservation practices.xlsx

Platte_CIA_Permits_Changes_updates.xlsx

A third spreadsheet, *Robust_COHYST_Platte_data.xlsx*, was also provided to TFG; however, information relevant to the Robust Review that was contained in that spreadsheet was also contained in the two above spreadsheets and thus *Robust_COHYST_Platte_data.xlsx* was not used as an independent source of information by TFG.

The spreadsheets summarized information related to multiple conservation programs and categorized information accordingly. For the purposes of the Robust Review, TFG needed to designate those categories as being either a retirement (either temporary or permanent) or a transfer. Tables 2-4 below provide a mapping of the categories which were assigned to either temporary or permanent retirements in Table 1. The column headers in the tables indicate the TBNRD assigned category mapped to the Table 1 column indicated by the title of the table. Those table titles are:

Table 2: Summary of temporary retirement acreage in the TBNRD - This is Column A in Table 1

Table 3: Summary of permanent retirement acreage in the TBNRD - This is Column C in Table 1

Table 4: Summary of temporary retirement acreage reinstated in the TBNRD - This is Column B in Table 1

Table 2. Summary of temporary retirement acreage in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
1999	-	1.9	-	-	-	-	1.9
2000	-	28.3	7.0	-	258.3	-	293.6
2001	-	-	-	-	408.6	-	408.6
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	77.5	-	-	77.5
2005	-	16.6	21.0	221.8	-	-	259.4
2006	-	-	17.9	116.0	-	30.0	163.9
2007	-	9.0	27.0	183.8	-	-	219.8
2008	126.8	-	13.0	400.5	-	157.5	697.8
2009	-	-	14.8	153.1	-	-	167.9
2010	-	-	-	127.3	-	-	127.3
2011	-	-	-	111.3	-	-	111.3
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

Table 3. Summary of permanent retirement acreage in the TBNRD

Year	Conservation Easements	Permanent Retirements
1999	-	-
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	73.1	73.1
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
Total	73.1	73.1

Table 4. Summary of temporary retirement acreage reinstated in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
2005	-	-	7.0	-	-	-	7.0
2006	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-
2008	-	-	-	77.5	-	-	77.5
2009	-	1.9	-	221.8	-	-	223.7
2010	-	28.3	21.0	116.0	258.3	-	423.6
2011	-	-	17.9	183.8	408.6	-	610.3
2012	-	-	27.0	400.5	-	-	427.5
2013	126.8	-	13.0	153.1	-	157.5	450.4
2014	-	-	14.8	127.3	-	-	142.1
2015	-	16.6	-	111.3	-	-	127.9
2016	-	-	-	-	-	-	-
2017	-	9.0	-	-	-	30.0	39.0
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

The information under the column names on Tables 2-4 all originated in the spreadsheets provided by the TBNRD with the exception of “DNR CREP/EQIP” which summarized processed information from NDNR. The spreadsheet *TBNRD AppendixI_Conservation practices .xlsx* contained the only reference to a category TFG assigned to permanent retirements. Key elements regarding that category along with a reference to the table the category is considered in are shown below.

Conservation Easements

- 2 entries
- Table 3

With regards to temporary retirement information from the TBNRD, following are a few key elements regarding each of those categories along with a reference to which table number(s) the category is considered. With the exception of the category “CRP Reinstatements”, information for all categories was taken from the file *TBNRD AppendixI_Conservation practices .xlsx*. As indicated below, the “CRP Reinstatements” information was taken from *Platte_CIA_Permits_Changes_updates.xlsx.*

Conservation Corners

- Contracts are for 5 years
- 11 entries
- Table 2 & Table 4

Buffer Strips

- Contracts are for 10 years
- 6 entries
- Table 2 & Table 4

Pheasants Forever

- Contract are for 5 years
- 15 entries
- Table 2 & Table 4

CRP Reinstatements – (Note data source was *Platte_CIA_Permits_Changes_updates.xlsx*)

- Assumed 10 year contract duration – provided information only specified when the acres were reinstated. No contract start date information was provided.
- 4 entries
- Table 2 & Table 4

CREP

- 1 entry
- The CREP entry was for 30 acres for the period 2006-2016. This entry was also in the DNR data set. The DNR data set was used due to the accompanying shape file.
- Table 2

TBNRD EQIP (EQIP)

- Contracts appears to be for 4 years
- 95 entries. Entries were cross referenced with information provided by NDNR to ensure acreage was neither double accounted for nor overlooked.
- Table 2 & Table 4

With regards to the CREP and EQIP programs, as indicated in the above discussion TFG received information from both the TBNRD and NDNR. To supplement the information provided by TBNRD, NDNR provided the shape file *CREP* on 8/17/2017. It was augmented by the spreadsheet *20170829_COHYSTAreaMissingDates.xlsx* provided on 8/29/2017 which provided additional contract start/end dates that were missing from the shape file attribute information.

This shape file included the most up to date list of CREP and EQIP contracts available from NDNR at that time. TFG spatially queried the data in the CREP shape file to obtain only the parcels located within the TBNRD. That query returned 114 parcels. Those parcels all had designations of either CREP, EQIP, or TBEQIP. Table 5 shows the number of acres represented by those 114 parcels.

Table 5. DNR CREP and EQIP temporary retirements within the TBNRD.

Year	CREP	EQIP	TBEQIP
2005	-	169.7	-
2006	1,029.8	-	-
2007	416.7	-	-
2008	16.6	-	380.1
2009	-	-	-
2010	2.6	-	-
Total	1,465.7	169.7	380.1

For inclusion in the Robust Review. the information was further limited to:

- Contracts initiated prior to the end of 2013
- Parcels located within the drainage area of the Platte River
- Contracts referencing acreage only irrigated with ground water

As a final QC step, the remaining records were compared to the information contained in the TBNRD spreadsheet *TBNRD AppendixI_Conservation practices.xlsx,* sheets 'EQIP D land' and 'CREP Acres'. The location and contract timing of the 'EQIP D land' records did not overlap with records in CREP shape file. The entry from 'CREP Acres', however, did match a record in the CREP shapefile. TFG elected to use the entry from the CREP shape file due to the spatial definition provided in the shapefile.

At the conclusion of this process, 21 parcels remained and were considered in the Robust Review. Table 6 below shows the number of acres represented by those parcels and are the values shown in columns "DNR CREP/EQIP" on Tables 2 and 4.

Table 6. DNR CREP and EQIP temporary retirements within the Platte River Basin area of the TBNRD.

Year	CREP	TBEQIP	End Year
2005	-	-	
2006	30.0	-	2017
2007	-	-	
2008	-	157.5	2013
2009	-	-	
2010	-	-	
Total	30.0	157.5	

<u>Data Source Discussion for Table 1 Columns D and E</u>

The information presented in Columns D and E of Table 1 represents the available acreage transfer information which was all provided to TFG in the spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx*.

The spreadsheet contained information regarding two types of transfers. The first type of transfer involved moving the source of the irrigation water, while the field where the irrigation water was applied remains unchanged. This type of transfer did not require any action to be taken for the Robust Review. These transfers were listed in the sheets ‘G Water Transf_Exsisting’ and ‘G Water Transfers’ within *Platte_CIA_Permits_Changes_updates.xlsx.*

The second type of transfer involved transferring the location of where the irrigation water was applied. These types of transfers were recorded on sheet ‘Acres Transfers’ in spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx*. The spreadsheet listed records for 109 such transfers. Of these, 25 occurred within a time frame that could have potentially impacted the 2011-2013 irrigation seasons. These records were compared to information on file at NDNR and TFG received confirmation on 11/14/2017 via email from NDNR that the TBNRD and NDNR information was in general agreement. Columns A and B in Table 7 below summarize that information.

Table 7. Summary of transfer acres in the TBNRD

TBNRD			To		From	
Year	(A) To	(B) From	(C) Current Year	(D) Next Year	(E) Current Year	(F) Next Year
2010	74.4	75.7	48.7	25.7	50.0	25.7
2011	158.0	158.0	153.0	5.0	153.0	5.0
2012	188.4	194.1	113.3	75.1	113.3	80.8
2013	234.3	250.8	154.3	80.0	164.8	86.0

The transfers represented on Table 7 occurred on or after July 1, 2010 and before July 1, 2013. This was based upon the ‘Date Approved’ field in the spreadsheet (*Platte_CIA_Permits_Changes_updates.xlsx*) information. For the purposes of inclusion in the Robust Review, it was decided that If the transfer occurred after July 1, it was likely that the original field was still irrigated in the transfer year; as the late year transfers typically happened in the fall (October-December). For transfers occurring on or before July 1, it was assumed that irrigation water was applied in the alternate (transfer) location. Columns C through F on Table 7 present a breakdown of the acreage based on the July 1 implementation date. Columns C and D partition the “Transfer To” acreage (Column A) while Columns E and F partition the “Transfer From” acreage (Column B). Table 8 presents summarizes the transfer acreage amounts after the July 1 timing criteria is applied.

Table 8. Summary of transfer acres in the TBNRD adjusted for timing within the year.

Adjusted		
Year	To	From
2011	178.7	178.7
2012	118.3	118.3
2013	229.4	245.6

The spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx* also contained information on wells converted for use for irrigation to use for watering livestock. The tab 'Conversion' in the spreadsheet contained four such entries, two of which occurred in the 2011-2013 timeframe. For the purposes of the Robust Review, those transactions were considered to be transfers. Table 9 incorporates these conversions with the Table 8 transfer information to provide the total Transfer To (Column A) and Transfer Away (Column D) values reflected on Table 1.

Table 9. Summary of transfer acres in the TBNRD

Year	(A) Transfer To	(B) Transfer Away	(C) Conversions	(D) Total Transfer Away
2011	178.7	178.7	67.9	246.7
2012	118.3	118.3	-	118.3
2013	229.4	168.5[1]	-	168.5
Total	526.4	465.6	67.9	533.5

Data Source Discussion for Table 1 Columns F through I

In addition to the information provided by TBNRD, the Central Platte Natural Resources District (CPNRD) identified retirements, transfers, and variances which were placed in cells assigned to the TBNRD in the Platte Basin. This information included transfers to (CPNRD Acres Added), permanent retirements (CPNRD Acres Offset WB), and temporary retirements (CPNRD CREP). The scope of these transactions is defined in Table 10, and depict the Non-TBNRD data in Table 1.

Table 10. DNR CREP and EQIP temporary retirements within the Platte River drainage Basin.

Year	CPNRD Acres Added	CPNRD Acres Offset WB	CPNRD CREP Retirement	CPNRD CREP Reinstatement
2009	-	149.1	0.7	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	1.4	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-
2019	-	-	-	-
2020	-	-	-	-
2021	-	-	-	0.7

[1] Transfer acres were subject to the same limitations as CREP/EQIP acreage. Table 13 traces the source of the 168.5 value for 2013.

Other Information Provided By TBNRD

The spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx* contained some additional information which was not included into the current Robust Review. The sheet 'Variances' summarized actions taken by the TBNRD which categorized as Variances. These actions tended to be administrative in nature rather than identifying acreage type changes. The POAC group decided in August 2017 to not consider these types of actions in the current Robust Review project.

The same spreadsheet also contained a sheet named 'Corrections' which contained a set of information regarding administrative changes related to the number of irrigated acres rather than changes to acreage locations. No action was taken on these entries.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers and variances to the COHYST model grid. This was accomplished either by overlaying the parcels' shape file with the model grid or linking the parcels' legal description to model cells.

Step 1: Assigning land use change locations within the model

Each of the transactions provided by TBNRD included a legal description. These descriptions typically included the quarter section in which the transaction took place. This information was linked to the COHYST 2010 model grid. COHYST uses a grid of 160-acre sized model cells; but, the cell boundaries and the section lines do not overlap. To accommodate this, the section shape file was spatially joined with the cell centroid. Typically, this would result in 4 cells being assigned to a section as represented on Table 11. Using the quarter section identifier, the cell which best represented the spatial location of the transaction was assigned the placement.[2]

Table 11. Approach used to link legal descriptions to model cell locations.

Cell Index	Row	Column	Quarter
Cell	x	y	NW
Cell + 1	x	y + 1	NE
Cell + 504	x + 1	y	SW
Cell + 505	x + 1	y + 1	SE

In a similar way the model cells were assigned to counties, NRDs, and drainage basins. In general, features were assigned to cells based on the location of the cell's centroid in relation to the border of interest. This results in a model cell being assigned a single value for a given feature class. For example, if the border of an NRD passes through a model cell, whichever NRD the cell's centroid is within determines which NRD the cell is assigned to within the model. For this reason, it is possible to have an activity which occurs within a cell along a feature border to be enacted by one entity that shares the border, but for the model to summarize the activity to the other entity which shares the border.

The data on Table 12 below illustrates just that type of effect. The acreage retirement information in Column A of Table 12 matches that shown in the 'TBNRD EQIP' column of Table 2. These again are retirements related to the EQIP program initiated by the TBNRD within the Platte Basin area of the District. However, when these actions are assigned within the model, a small number of acres are assigned to cells which have been assigned to a river basin outside of the Platte Basin. Columns B and C in Table 12 present the effect of this distribution within the model (Column B – acreage distributed to cells assigned within the model to be in the Platte Basin drainage area; Column C – acreage distributed to cells assigned within the model to a drainage basin outside of the Platte Basin). Likewise, Column D matches the acreage reinstatement information shown in the 'TBNRD EQIP' column of Table 4. Columns E and F reflect the distribution of that acreage inside of and outside of the Platte Basin, respectively.

[2] For irregular sections, the cell-section relationship and professional judgement was used to place the transaction acres as close as possible to the defined location.

Table 12. Distribution of the TBNRD EQIP acres between the Platte River Basin and the rest of the NRD[3].

Year	(A) Total EQUP TBNRD Retirements	(B) EQIP TBNRD Platte Basin Retirements	(C) EQIP TBNRD Non-Platte Basin Retirements	(D) Total EQUP TBNRD Reinstatements	(E) EQIP TBNRD Platte Basin Reinstatements	(F) EQIP TBNRD Non-Platte Basin Reinstatements
2004	77.5	50.0	27.5	-	-	-
2005	221.8	221.8	-	-	-	-
2006	116.0	116.0	-	-	-	-
2007	183.8	183.8	-	-	-	-
2008	400.5	400.5	-	77.5	50.0	27.5
2009	153.1	116.1	37.0	221.8	221.8	-
2010	127.3	127.3	-	116.0	116.0	-
2011	111.3	111.3	-	183.8	183.8	-
2012	-	-	-	400.5	400.5	-
2013	-	-	-	153.1	116.1	37.0
2014	-	-	-	127.3	127.3	-
2015	-	-	-	111.3	111.3	-
Total	1,391.3	1,326.8	64.5	1,391.3	1,326.8	64.5

The distribution of the Transfer Acres summarized in Table 8 encountered a similar issue. The acreage values in Column A on Table 13 matches those shown in the column 'From' in Table 8. Columns B and C in Table 13 reflect the distribution of those acres to cells defined as being either within the CPNRD (Column B) or the TBNRD (Column C). The acreage listed in Column C is then summarized based on whether the distribution placed the acreage within cells identified as being within either the Platte Basin (Column D) or outside of the Platte Basin (Column E) areas of the TBNRD.

Table 13. Distribution of TBNRD transfers away between applied NRDs and river basins[4].

Year	(A) Transfer Away Total	(B) Applied in CPNRD	(C) Applied In TBNRD	(D) TBNRD Platte	(E) TBNRD Non-Platte
2011	178.7	-	178.7	178.7	-
2012	118.3	-	118.3	118.3	-
2013	245.6	77.1	168.5	160.3	8.2

[3]TBNRD only provided EQIP contracts acreage for the Platte River Basin. However, some of these acres, while in the Platte Basin, were assigned to cells which were not in the Platte Basin. This is caused by the drainage boundary differing from cell boundaries.

[4] TBNRD only provided transfer acreage for the Platte River Basin. However, some of these acres, while in the Platte Basin, were assigned to cells which were not in the Platte Basin. This is caused by the drainage boundary differing from cell boundaries.

Step 2: Building the Baseline Land Use Update

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update is the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all the temporarily retired acres.[5]

Acres were to be added or removed from their assigned cells. If there was insufficient space[6] for new acres or an insufficient amount of groundwater only acres[7] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[8]. This spatial analysis process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. This occurs unless an even split would exceed the available space within a given cell at which time the placed acres would be limited to the available space and the remaining acres would be evenly split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom FORTRAN script.

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres.

[5] 2023 was identified as the year the last temporary retirement would be actively irrigated again for the first time
[6] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres
[7] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres
[8] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

The results of Step 2 are shown in Table 14. As intended, the values in Column B of Table 14 match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column J of Table 1 for the years 2011-2023. This indicates that the acreage values provided by TBNRD and NDNR were the quantities by which the modeling input files were adjusted. The value in Column C of Table 14 matches the value in Column B of Table 13 which again indicates that the model input files were adjusted by the intended values based on the results of the spatial distribution assignments made to the provided input data from TBNRD. As an aside, the distribution routines placed 58.6 of the 77.1 acres shown in Table 14 Column C into Dawson county and the remaining 18.5 acres into Buffalo county.

Table 14. Change in groundwater only irrigated acres within the TBNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in TBNRD	(B) Annual Change in TBNRD Groundwater Only Irrigated Acres in the TBNRD	(C) Change in TBNRD Groundwater Only Irrigated Acres not in the TBNRD
2010	459,902.8	-	-
2011	460,333.9	431.1	-
2012	460,761.2	427.3	-
2013	461,273.7	512.5	(77.1)
2014	461,415.8	142.1	-
2015	461,543.7	127.9	-
2016	461,543.7	-	-
2017	461,582.7	39.0	-
2018	461,582.7	-	-
2019	461,582.7	-	-
2020	461,582.7	-	-
2021	461,583.4	0.7	-
2022	461,583.4	-	-
2023	461,583.4	-	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

Similarly, a new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired. Other key elements of the scenario include:

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retired acres added back in 2011 remain moving forward.

Table 15 shows the changes between the COHYST 2010 land use data set (Column A) and the unretired retirements scenario data set (Column B). The difference between the two data sets is a result of incorporating the retirement and transfer acreage information into the model. Again as intended, the annual change in ground water only acres shown on Table 15 (Column D) match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column J of Table 1 for the years 1999-2010 (the sign reversal indicates removal (unretirement) of the acreage). This indicates that the acreage values provided by TBNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 15. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres	
Year	(A) Run029	(B) Modified Land Use	(C) Cumulative	(D) Annual
1999	408,126	408,128	1.9	1.9
2000	409,469	409,764	295.5	293.6
2001	409,418	410,122	704.1	408.6
2002	421,829	422,533	704.1	0.0
2003	422,302	423,007	704.2	0.1
2004	423,360	424,142	781.8	77.6
2005	422,424	423,458	1,033.9	252.1
2006	439,644	440,842	1,197.9	164.0
2007	464,704	466,122	1,418.0	220.1
2008	444,988	447,099	2,111.4	693.4
2009	471,247	473,452	2,204.8	93.4
2010	459,903	461,811	1,908.6	(296.2)
		Cumulative		1,908.6

Table 16 shows the changes between the annual COHYST 2010 land use files and the land use files developed for the "unretired" condition within the Robust Review's retirement scenario. Column A in the table presents the annual acreage irrigated only with ground water from 2011 through 2023 for the "unretired" land use data set. Column B summarizes the acreage changes made to arrive at values presented in Column A. Columns C through I present the information used in the computation of the Column B values.

SUMMARY

Tables 14 through 16 summarize the background information as to how the land use files for the Robust Review will be populated. Comparisons back to Table 1 confirm the information provided to TFG by TBNRD, NDNR and other entities referenced in the memorandum were fully included in the model input files. The retirement scenario within the Robust Review involves two land use datasets: the Baseline Set; and the Unretired Set.

For the Baseline Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column A in Table 15 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 14 will be used

For the Unretired Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column B in Table 15 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 16 will be used

Table 16. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2013.

Year	(A) Groundwater Only Irrigated Acres	(B) =I-G Difference in Groundwater only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away (Table 9, Col D And Table 13, Col D)	(D) Transfers to (Table 9, Col A)	(E) Non Area Transfers Away (Table 13, Col E)	(F) Non Area Transfers To (Table 10)	(G) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Residuals
2011	461,743.5	(67.9)	246.7[9]	178.7	-	-	67.9	67.9	0.4
2012	461,743.4	(0.1)	118.3[10]	118.3	-	-	-	67.9	(0.1)
2013	461,805.6	62.2	160.3[11]	229.4	8.2	1.4	(62.3)	5.7	(0.1)
2014	461,805.6	-					-	5.7	-
2015	461,805.6	-					-	5.7	-
2016	461,805.6	-					-	5.7	-
2017	461,805.6	-					-	5.7	-
2018	461,805.6	-					-	5.7	-
2019	461,805.6	-					-	5.7	-
2020	461,805.6	-					-	5.7	-
2021	461,805.6	-					-	5.7	-
2022	461,805.6	-					-	5.7	-
2023	461,805.6	-					-	5.7	-

[9] Table 9, Column D
[10] Table 9, Column D
[11] Table 13, Column D

Tables 17 and 18 show the annual area of groundwater only irrigated land for each county in the TBNRD within the Robust Review's baseline and unretirement scenarios. Finally, Tables 19 and 20 show the annual area of groundwater only irrigated land for each county in the TBNRD within the Platte River Drainage basin.

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,325	165,623
2000	64,020	179,822	165,627
2001	64,705	179,524	165,188
2002	65,456	187,438	168,936
2003	66,229	187,575	168,498
2004	67,007	187,705	168,648
2005	67,899	187,429	167,096
2006	70,272	196,922	172,450
2007	85,141	200,533	179,031
2008	74,647	198,594	171,748
2009	91,432	200,132	179,683
2010	83,058	197,888	178,957
2011	83,049	198,313	178,972
2012	83,156	198,376	179,230
2013	83,199	198,508	179,567
2014	83,274	198,508	179,634
2015	83,274	198,524	179,746
2016	83,274	198,524	179,746
2017	83,274	198,524	179,785
2018	83,274	198,524	179,785
2019	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,327	165,623
2000	64,020	180,099	165,646
2001	64,705	180,210	165,207
2002	65,456	188,123	168,955
2003	66,229	188,261	168,517
2004	67,007	188,468	168,667
2005	67,906	188,232	167,320
2006	70,330	197,742	172,769
2007	85,216	201,384	179,523
2008	74,828	199,550	172,721
2009	91,811	201,080	180,561
2010	83,454	198,549	179,809
2011	83,428	198,529	179,786
2012	83,428	198,529	179,786
2013	83,423	198,598	179,785
2014	83,423	198,598	179,785
2015	83,423	198,598	179,785
2016	83,423	198,598	179,785
2017	83,423	198,598	179,785
2018	83,423	198,598	179,785
2019	83,423	198,598	179,785

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2020	83,274	198,524	179,785
2021	83,274	198,524	179,785
2022	83,274	198,524	179,785
2023	83,274	198,524	179,785
2024	83,274	198,524	179,785
2025	83,274	198,524	179,785
2026	83,274	198,524	179,785
2027	83,274	198,524	179,785
2028	83,274	198,524	179,785
2029	83,274	198,524	179,785
2030	83,274	198,524	179,785
2031	83,274	198,524	179,785
2032	83,274	198,524	179,785
2033	83,274	198,524	179,785
2034	83,274	198,524	179,785
2035	83,274	198,524	179,785
2036	83,274	198,524	179,785
2037	83,274	198,524	179,785
2038	83,274	198,524	179,785
2039	83,274	198,524	179,785
2040	83,274	198,524	179,785
2041	83,274	198,524	179,785
2042	83,274	198,524	179,785
2043	83,274	198,524	179,785
2044	83,274	198,524	179,785
2045	83,274	198,524	179,785
2046	83,274	198,524	179,785
2047	83,274	198,524	179,785
2048	83,274	198,524	179,785
2049	83,274	198,524	179,785
2050	83,274	198,524	179,785
2051	83,274	198,524	179,785
2052	83,274	198,524	179,785
2053	83,274	198,524	179,785
2054	83,274	198,524	179,785
2055	83,274	198,524	179,785
2056	83,274	198,524	179,785
2057	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
2020	83,423	198,598	179,785
2021	83,423	198,598	179,785
2022	83,423	198,598	179,785
2023	83,423	198,598	179,785
2024	83,423	198,598	179,785
2025	83,423	198,598	179,785
2026	83,423	198,598	179,785
2027	83,423	198,598	179,785
2028	83,423	198,598	179,785
2029	83,423	198,598	179,785
2030	83,423	198,598	179,785
2031	83,423	198,598	179,785
2032	83,423	198,598	179,785
2033	83,423	198,598	179,785
2034	83,423	198,598	179,785
2035	83,423	198,598	179,785
2036	83,423	198,598	179,785
2037	83,423	198,598	179,785
2038	83,423	198,598	179,785
2039	83,423	198,598	179,785
2040	83,423	198,598	179,785
2041	83,423	198,598	179,785
2042	83,423	198,598	179,785
2043	83,423	198,598	179,785
2044	83,423	198,598	179,785
2045	83,423	198,598	179,785
2046	83,423	198,598	179,785
2047	83,423	198,598	179,785
2048	83,423	198,598	179,785
2049	83,423	198,598	179,785
2050	83,423	198,598	179,785
2051	83,423	198,598	179,785
2052	83,423	198,598	179,785
2053	83,423	198,598	179,785
2054	83,423	198,598	179,785
2055	83,423	198,598	179,785
2056	83,423	198,598	179,785
2057	83,423	198,598	179,785

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2058	83,274	198,524	179,785
2059	83,274	198,524	179,785
2060	83,274	198,524	179,785
2061	83,274	198,524	179,785
2062	83,274	198,524	179,785
2063	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
2058	83,423	198,598	179,785
2059	83,423	198,598	179,785
2060	83,423	198,598	179,785
2061	83,423	198,598	179,785
2062	83,423	198,598	179,785
2063	83,423	198,598	179,785

*Up to 70 acres occur in a cell assigned to TBNRD and Frontier County. This data was combined into the Gosper County total.

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1950	-	1,451	2,284
1951	-	2,756	2,526
1952	-	4,471	2,559
1953	-	5,672	3,353
1954	-	6,037	4,573
1955	-	8,107	5,669
1956	-	9,964	7,426
1957	-	11,608	10,599
1958	-	13,579	10,809
1959	695	15,597	11,822
1960	1,305	15,765	12,299
1961	1,826	15,948	13,191
1962	2,290	15,959	13,547
1963	2,819	16,120	15,229
1964	3,262	16,387	16,483
1965	4,568	19,419	20,599
1966	6,203	21,983	25,050
1967	7,199	24,714	28,886
1968	8,025	26,725	32,380
1969	8,997	29,610	36,325
1970	9,808	31,757	38,917
1971	10,618	34,429	41,562
1972	10,753	37,051	45,541

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1950	-	1,451	2,284
1951	-	2,756	2,526
1952	-	4,471	2,559
1953	-	5,672	3,353
1954	-	6,037	4,573
1955	-	8,107	5,669
1956	-	9,964	7,426
1957	-	11,608	10,599
1958	-	13,579	10,809
1959	695	15,597	11,822
1960	1,305	15,765	12,299
1961	1,826	15,948	13,191
1962	2,290	15,959	13,547
1963	2,819	16,120	15,229
1964	3,262	16,387	16,483
1965	4,568	19,419	20,599
1966	6,203	21,983	25,050
1967	7,199	24,714	28,886
1968	8,025	26,725	32,380
1969	8,997	29,610	36,325
1970	9,808	31,757	38,917
1971	10,618	34,429	41,562
1972	10,753	37,051	45,541

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1973	11,543	38,343	48,751
1974	12,240	40,953	53,046
1975	13,730	43,895	58,392
1976	15,050	46,039	62,503
1977	15,785	47,810	67,858
1978	16,792	50,036	71,705
1979	17,321	52,080	75,671
1980	17,678	55,399	79,706
1981	18,191	57,014	81,229
1982	18,530	58,737	83,636
1983	18,829	58,430	84,575
1984	18,824	57,783	84,309
1985	18,855	56,061	82,805
1986	18,668	55,868	82,479
1987	16,997	55,412	81,675
1988	17,219	56,116	82,625
1989	17,767	56,887	84,145
1990	18,190	57,348	85,113
1991	18,662	58,639	85,833
1992	19,290	60,028	87,456
1993	19,225	60,647	88,224
1994	19,512	61,398	88,644
1995	19,482	61,940	89,048
1996	19,777	62,572	89,715
1997	19,826	63,559	90,195
1998	21,061	63,366	90,027
1999	21,145	63,384	89,796
2000	21,261	63,445	89,849
2001	21,240	63,304	89,638
2002	20,818	66,058	91,450
2003	20,419	65,563	91,187
2004	20,024	65,338	90,602
2005	19,739	66,054	90,123
2006	20,443	67,863	93,694
2007	23,309	69,246	96,783
2008	19,770	67,654	94,781
2009	24,102	68,433	97,068

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1973	11,543	38,343	48,751
1974	12,240	40,953	53,046
1975	13,730	43,895	58,392
1976	15,050	46,039	62,503
1977	15,785	47,810	67,858
1978	16,792	50,036	71,705
1979	17,321	52,080	75,671
1980	17,678	55,399	79,706
1981	18,191	57,014	81,229
1982	18,530	58,737	83,636
1983	18,829	58,430	84,575
1984	18,824	57,783	84,309
1985	18,855	56,061	82,805
1986	18,668	55,868	82,479
1987	16,997	55,412	81,675
1988	17,219	56,116	82,625
1989	17,767	56,887	84,145
1990	18,190	57,348	85,113
1991	18,662	58,639	85,833
1992	19,290	60,028	87,456
1993	19,225	60,647	88,224
1994	19,512	61,398	88,644
1995	19,482	61,940	89,048
1996	19,777	62,572	89,715
1997	19,826	63,559	90,195
1998	21,061	63,366	90,027
1999	21,145	63,386	89,796
2000	21,261	63,722	89,867
2001	21,240	63,990	89,657
2002	20,818	66,744	91,469
2003	20,419	66,248	91,206
2004	20,024	66,076	90,621
2005	19,746	66,831	90,346
2006	20,501	68,656	94,013
2007	23,384	70,069	97,274
2008	19,952	68,610	95,747
2009	24,444	69,381	97,937

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2010	23,088	68,924	96,526
2011	23,080	69,349	96,541
2012	23,186	69,411	96,793
2013	23,192	69,552	97,129
2014	23,267	69,552	97,196
2015	23,267	69,568	97,307
2016	23,267	69,568	97,307
2017	23,267	69,568	97,346
2018	23,267	69,568	97,346
2019	23,267	69,568	97,346
2020	23,267	69,568	97,346
2021	23,268	69,568	97,346
2022	23,268	69,568	97,346
2023	23,268	69,568	97,346
2024	23,268	69,568	97,346
2025	23,268	69,568	97,346
2026	23,268	69,568	97,346
2027	23,268	69,568	97,346
2028	23,268	69,568	97,346
2029	23,268	69,568	97,346
2030	23,268	69,568	97,346
2031	23,268	69,568	97,346
2032	23,268	69,568	97,346
2033	23,268	69,568	97,346
2034	23,268	69,568	97,346
2035	23,268	69,568	97,346
2036	23,268	69,568	97,346
2037	23,268	69,568	97,346
2038	23,268	69,568	97,346
2039	23,268	69,568	97,346
2040	23,268	69,568	97,346
2041	23,268	69,568	97,346
2042	23,268	69,568	97,346
2043	23,268	69,568	97,346
2044	23,268	69,568	97,346
2045	23,268	69,568	97,346
2046	23,268	69,568	97,346

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2010	23,447	69,584	97,371
2011	23,421	69,565	97,348
2012	23,421	69,565	97,348
2013	23,417	69,641	97,346
2014	23,417	69,641	97,346
2015	23,417	69,641	97,346
2016	23,417	69,641	97,346
2017	23,417	69,641	97,346
2018	23,417	69,641	97,346
2019	23,417	69,641	97,346
2020	23,417	69,641	97,346
2021	23,417	69,641	97,346
2022	23,417	69,641	97,346
2023	23,417	69,641	97,346
2024	23,417	69,641	97,346
2025	23,417	69,641	97,346
2026	23,417	69,641	97,346
2027	23,417	69,641	97,346
2028	23,417	69,641	97,346
2029	23,417	69,641	97,346
2030	23,417	69,641	97,346
2031	23,417	69,641	97,346
2032	23,417	69,641	97,346
2033	23,417	69,641	97,346
2034	23,417	69,641	97,346
2035	23,417	69,641	97,346
2036	23,417	69,641	97,346
2037	23,417	69,641	97,346
2038	23,417	69,641	97,346
2039	23,417	69,641	97,346
2040	23,417	69,641	97,346
2041	23,417	69,641	97,346
2042	23,417	69,641	97,346
2043	23,417	69,641	97,346
2044	23,417	69,641	97,346
2045	23,417	69,641	97,346
2046	23,417	69,641	97,346

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2047	23,268	69,568	97,346
2048	23,268	69,568	97,346
2049	23,268	69,568	97,346
2050	23,268	69,568	97,346
2051	23,268	69,568	97,346
2052	23,268	69,568	97,346
2053	23,268	69,568	97,346
2054	23,268	69,568	97,346
2055	23,268	69,568	97,346
2056	23,268	69,568	97,346
2057	23,268	69,568	97,346
2058	23,268	69,568	97,346
2059	23,268	69,568	97,346
2060	23,268	69,568	97,346
2061	23,268	69,568	97,346
2062	23,268	69,568	97,346
2063	23,268	69,568	97,346

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2047	23,417	69,641	97,346
2048	23,417	69,641	97,346
2049	23,417	69,641	97,346
2050	23,417	69,641	97,346
2051	23,417	69,641	97,346
2052	23,417	69,641	97,346
2053	23,417	69,641	97,346
2054	23,417	69,641	97,346
2055	23,417	69,641	97,346
2056	23,417	69,641	97,346
2057	23,417	69,641	97,346
2058	23,417	69,641	97,346
2059	23,417	69,641	97,346
2060	23,417	69,641	97,346
2061	23,417	69,641	97,346
2062	23,417	69,641	97,346
2063	23,417	69,641	97,346

Memorandum

To: Ann Dimmit – TPNRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 11/21/2018
Subject: COHYST Area Robust Review: TPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Twin Platte NRD (TPNRD).

To account for transfers, retirements, and variances within the TPNRD, TFG's primary work tasks included evaluating and summarizing the available datasets related to transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013; and to then create a new land use data set for the unretired acreage scenario. For the first step in the process, TFG worked with NDNR and TPNRD to gather the land use data (retirements, transfers, and variances) and place into summary tables by land use type. TFG's next steps were to perform geospatial analyses using ArcGIS to identify the location of each transaction. The geospatial analysis included a proximity function in the form of a custom Fortran program to determine the closest available model cells capable of accommodating the specified land use change.

This memorandum presents a series of tables which summarize the annual number of acres retired or transferred within the TPNRD, outlines the spatial analysis methodology, and ultimately summarizes the resultant land use files.

Land Use Summary Tables

Using information provided by TPNRD and the NDNR, TFG compiled a final summary of the retirements, transfers, and variances for the TPNRD. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-4 below summarize the information provided to TFG. Tables 5-11 summarize the distribution of that information into the modeling input files.

Table 1 shows an overview summary of retirements and transfers in the TPNRD. Tables 2, 3, and 4 show summaries of the individual categories used to create Table 1 and serve as a reference for the description of each data source.

Table 1. Summary of TPNRD acreage changes for implementation into the Robust Review.

Year	Temporary Retirements	Reinstated Temporary Retirements	Transfers To	Transfers Away	Change
Baseline Change	(-)	(+)	(+)	(-)	
2006	595.5	-	-	-	(595.5)
2007	27.4	-	-	-	(27.4)
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	833.2	815.6	17.6
2012	40.8	28.8	1,569.5	1,635.5	(78.0)
2013	-	-	1,865.3	1,840.5	24.8
2014	-	-	-	-	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	-	594.1	-	-	594.1
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	-	-	-	-	-
2023	-	40.8	-	-	40.8
Total	663.7	663.7	4,268.0	4,291.6	(23.6)

The TPNRD provided two shape files on 8/8/2017 which summarized acreage transfers in the District:

TPNRD_Acres_Decertified_Implemented_through_2013 – (Transfers Away)

TPNRD_New_Acres_implemented_through_2013 – (Transfers To)

These two files provided the spatial location of the acreage transfers within the TPNRD.

Key elements from the information provided related to Decertified Acres (Transfers Away in Table 1):

- 229 entries
- 149 of the 229 entries occurred between 2011 and 2013
- Timing was based upon the implementation year
- In 2013, 234.3 decertified acres were located outside the COHYST 2010 active model domain. They were not considered when modifying the land use.
- 5.4 decertified acres were removed from cells assigned to the CPNRD; 1.6 acres in 2011 and 3.8 acres in 2012
- Table 2 summarizes the model areas impacted by the provided information

Key Elements form the information provided related to New Acres (Transfers To in Table 1):

- 187 entries
- 131 of the 187 entries occurred between 2011 and 2013
- Timing was based upon the implementation year
- 11.4 acres were added to cells assigned to the URNRD. All 11.4 acres were added in 2011.
- Table 3 summarizes the model areas impacted by the provided information

Table 2. Summary of decertified transfer acres in the TPNRD

Year	Decertified Acres	Decertified Acres in Non-Active Cells	Modeled Decertified Acres	Removed from TPNRD	Removed From CPNRD
2011	815.6	-	815.6	814.0	1.6
2012	1,635.5	-	1,635.5	1,631.7	3.8
2013	2,074.8	234.3	1,840.5	1,840.5	-
Total	4,525.9	234.3	4,291.6	4,286.2	5.4

Table 3. Summary of new transfer acres in the TPNRD

Year	New Acres	Added To TPNRD	Added to URNRD
2011	833.2	821.8	11.4
2012	1,569.5	1,569.5	-
2013	1,865.3	1,865.3	-
Total	4,268.0	4,256.6	11.4

Temporary retirement information recorded on Table 1 was based on information NDNR provided on 8/17/2017 in the form of a shape file which summarized CREP and EQIP contract information.

This shape file included the updated list of CREP and EQIP contracts. The data was clipped to the TPNRD resulting in 59 polygons totaling 1,641 acres. The information was limited to groundwater only irrigated (Irrigation = 1) lands which trimmed the area to 14 polygons and 905 acres. Finally, the polygons were reduced to those which were initiated prior to the 2013 irrigation season. This left the data set with 11 entries with 663.7 acres. Each of these 11 entries were CREP contracts. Contract lengths were either 5, 10, or 11 years (Table 4).

To be considered for the current year, the retirement needed to be initiated or ended prior to July of the current year; otherwise, the transaction will have its first effect in the next year. The rationale is that if the action was taken prior to July, the transaction could influence the irrigation season in the current year. However, if the transaction occurred later, the land would finish up the current growing season in the same state.

Table 4. Summary of temporary retirements and reinstated retirement acres in the TPNRD

Year	Temporary Retirements	Reinstated Retirements
2006	595.5	-
2007	27.4	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	40.8	28.8
2013	-	-
2014	-	-
2015	-	-
2016	-	-
2017	-	594.1
2018	-	-
2019	-	-
2020	-	-
2021	-	-
2022	-	-
2023	-	40.8
Total	663.7	663.7

As discussed above, the acreage summarized in Table 1 (developed from the information in Tables 2-4) was provided in a series of GIS shape files. Using standard GIS practices, the acreage polygons within these coverages were unioned with the COHYST 2010 model grid to determine the number of acres in each model grid cell for each transaction. The following section provides additional detail on this process.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers, and variances to the COHYST model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

NDNR and TPNRD provided shape files for their retirements and transfers. The union function within ArcGIS was applied to the shapefiles to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS.

Step 2: Building the Baseline Land Use

The next step was to build the 2011-2013 baseline land use files incorporating the identified transfers and retirements. The beginning condition for this update was the 2010 land use file from the COHYST 2010 model. Each of the transactions occurring in 2011 were applied to the existing 2010 land use file to create the 2011 land use file; which in turn became the basis for applying the transactions occurring in 2012. This continued through 2013. One of the key points of the investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 in order to accurately reflect the temporary nature of the retirements. [1]

In the process of distributing the GIS polygon information to the model cells, the existing acreage within a given cell in the year 2010 (as modified moving forward through 2013 as discussed above) was considered. If there was insufficient space[2] for new acres or an insufficient amount of groundwater only acres[3] to be retired within a given cell, the addition or subtraction of acres was applied to nearby cells which exhibited the appropriate characteristics[4]. This spatial analysis process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom FORTRAN script.

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[1] 2023 was identified as the year the last TPNRD temporary retirement would be actively irrigated again for the first time

[2] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres available

[3] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres identified

[4] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. 'r' and 'c' indicate the row column index of the cell.

Table 5 presents the results of Step 2 above. The values in Table 5 were generated by summarizing information from the model land use input files (created as described above) developed for the baseline (full representation of all acreage retirements/transfers) Robust Review model run. Comparing Table 5 to Table 1 shows how the provided information was ultimately represented in the model for the years 2011 – 2023. Discrepancies between the tables are generally related to a particular cell's NRD assignment within the model. In 2011, the location of a couple of transactions were placed in cells designated CPNRD or URNRD; 11.4 new acres were placed in the URNRD in Perkins County, while 1.6 acres were removed from CPNRD in Dawson County. Likewise, in 2012, 3.8 acres were removed from CPNRD in Dawson County. These placements were from the New Acres(Transfers To in Table 1) and Decertified Acres (Transfers Away in Table 1) data sets.

It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 5. Change in groundwater only irrigated acres within the TPNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in TPNRD	(B) Annual Change in TPNRD Groundwater Only Irrigated Acres in the TPNRD	(C) Change in TPNRD Groundwater Only Irrigated Acres not in the TPNRD
2010	263,165.7	-	-
2011	263,173.8	8.1	9.8
2012	263,099.6	(74.2)	(3.8)
2013	263,124.4	24.8	-
2014	263,124.4	-	-
2015	263,124.4	-	-
2016	263,124.4	-	-
2017	263,718.3	593.9	-
2018	263,718.3	-	-
2019	263,718.3	-	-
2020	263,718.3	-	-
2021	263,718.3	-	-
2022	263,718.3	-	-
2023	263,759.1	40.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

Step 3 was taken to develop a new set of land use files for the unretired scenario within the Robust Review. Key elements related to the construction of this scenario include:

a) Acreage transfers were applied as the historically occurred.
b) Post 2010, no acreage retirement activities were incorporated.
c) For temporary and permanent retirements initiated prior to 2010, irrigated acres were added back into the modified land use files starting with the first retirement year (e.g. if a retirement started in 2008, the retired acres were added back into the model starting in 2008).

Regarding c) above, Table 6 shows the changes between the COHYST 2010 land use (column “Run029” in Table 6) and the unretired retirements scenario (column “Modified Land Use” in Table 6). The difference between the two data sets shows the cumulative change over time. These values match those shown in Table 1 subject to rounding resulting from the distribution process.

Table 6. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

Year	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres within the TPNRD	
	Run 029	Modified Land Use	Cumulative	Annual
1999	208,718	208,718	-	-
2000	210,934	210,934	-	-
2001	213,311	213,311	-	-
2002	221,892	221,892	-	-
2003	233,442	233,442	-	-
2004	245,508	245,508	-	-
2005	250,480	250,480	-	-
2006	258,475	259,070	595.4	595.4
2007	267,919	268,541	622.6	27.2
2008	265,482	266,105	622.7	0.1
2009	267,862	268,485	622.7	(0.0)
2010	263,166	263,788	622.7	0.0
		Cumulative		622.7

With regards to b) under Step 3, Table 7 show the changes referenced to the year 2010 between the COHYST 2010 land use file and the unretired acres represented in the retirement scenario land use file for the Robust Review. The table presents an annual summary for the years 2011 – 2023 of the modifications made to the number of acres irrigated only with ground water based on the 2010 acreage.

Column (A) of Table 7 presents a summary taken from the model input files of the total number of acres irrigated only with ground water represented within the NRD in the “unretired condition” of the retirement scenario. This column can be contrasted with Column (A) of Table 5 to see the total annual acreage change represented in the model between the baseline (all retirements included) condition (Table 5) and the “unretired” scenario condition (Table 7) for the years 2011 through 2023.

Column (B) of Table 7 presents the annual change made to the preceding year’s acreage total for determining a given year’s adjusted acreage value. Column (B) was calculated using the values in Columns (C) through (I).

Table 7. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2023.

Year	(A) Groundwater Only Irrigated Acres	(B) =-((G)-(I)) Difference in Groundwater only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away (Table 2)	(D) Transfers to (Table 3)	(E) Non Area Transfers Away	(F) Non Area Transfers To	(G) =(C)–(D) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Rounding Residuals
2011	263,796.5	8.1	814.0	821.8			(7.8)	(7.8)	0.3
2012	263,734.4	(62.1)	1,631.7	1,569.5			62.2	54.4	0.1
2013	263,759.2	24.8	1,840.5	1,865.3			(24.8)	29.6	(0.0)
2014	263,759.2	-					-	29.6	-
2015	263,759.2	-					-	29.6	-
2016	263,759.2	-					-	29.6	-
2017	263,759.2	-					-	29.6	-
2018	263,759.2	-					-	29.6	-
2019	263,759.2	-					-	29.6	-
2020	263,759.2	-					-	29.6	-
2021	263,759.2	-					-	29.6	-
2022	263,759.2	-					-	29.6	-
2023	263,759.2	-					-	29.6	-

Tables 8 and 9 show the annual area of groundwater only irrigated land for each county in the TPNRD within the Robust Review's baseline and unretirement scenarios. Finally, Tables 10 and11 show the annual area of groundwater only irrigated land for each county in the TPNRD and Platte River Drainage basin within the Robust Review's baseline and unretirement scenarios.

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,873	8,285	140
1957	280	10,202	10,006	140
1958	237	10,809	11,681	140
1959	259	11,064	13,596	140
1960	280	12,154	13,940	140
1961	358	12,975	13,933	280
1962	365	14,036	14,258	280
1963	336	15,026	14,721	420
1964	330	15,865	14,864	420
1965	420	18,019	17,328	420
1966	399	19,825	19,369	420
1967	549	22,606	21,894	420
1968	906	24,595	23,982	700
1969	1,159	26,818	26,102	840
1970	1,400	28,644	31,203	980
1971	1,839	30,082	35,802	980
1972	1,818	31,813	40,612	980

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,873	8,285	140
1957	280	10,202	10,006	140
1958	237	10,809	11,681	140
1959	259	11,064	13,596	140
1960	280	12,154	13,940	140
1961	358	12,975	13,933	280
1962	365	14,036	14,258	280
1963	336	15,026	14,721	420
1964	330	15,865	14,864	420
1965	420	18,019	17,328	420
1966	399	19,825	19,369	420
1967	549	22,606	21,894	420
1968	906	24,595	23,982	700
1969	1,159	26,818	26,102	840
1970	1,400	28,644	31,203	980
1971	1,839	30,082	35,802	980
1972	1,818	31,813	40,612	980

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
1973	1,933	33,438	45,704	1,260
1974	2,203	35,177	50,349	1,540
1975	2,881	40,123	57,650	1,540
1976	3,068	46,074	62,725	1,540
1977	3,912	52,163	69,618	1,820
1978	5,277	57,650	76,349	2,940
1979	5,602	59,990	78,875	3,560
1980	6,470	62,452	82,621	4,158
1981	7,300	65,245	85,496	4,387
1982	7,653	67,611	88,954	4,746
1983	7,551	67,158	88,061	4,972
1984	7,670	67,173	85,653	5,350
1985	10,496	59,997	98,168	4,987
1986	10,513	60,079	97,769	5,094
1987	10,691	59,892	96,995	5,263
1988	10,714	61,442	97,483	5,323
1989	10,824	63,871	98,705	5,380
1990	10,845	65,847	99,915	5,438
1991	10,868	67,211	100,718	5,494
1992	10,906	68,534	102,556	5,573
1993	10,929	69,355	103,469	5,561
1994	11,067	71,249	104,183	5,550
1995	11,209	72,978	105,622	5,545
1996	11,461	75,348	108,418	5,541
1997	11,506	78,805	109,820	5,541
1998	11,206	79,530	111,264	5,226
1999	10,793	80,715	112,223	4,987

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
1973	1,933	33,438	45,704	1,260
1974	2,203	35,177	50,349	1,540
1975	2,881	40,123	57,650	1,540
1976	3,068	46,074	62,725	1,540
1977	3,912	52,163	69,618	1,820
1978	5,277	57,650	76,349	2,940
1979	5,602	59,990	78,875	3,560
1980	6,470	62,452	82,621	4,158
1981	7,300	65,245	85,496	4,387
1982	7,653	67,611	88,954	4,746
1983	7,551	67,158	88,061	4,972
1984	7,670	67,173	85,653	5,350
1985	10,496	59,997	98,168	4,987
1986	10,513	60,079	97,769	5,094
1987	10,691	59,892	96,995	5,263
1988	10,714	61,442	97,483	5,323
1989	10,824	63,871	98,705	5,380
1990	10,845	65,847	99,915	5,438
1991	10,868	67,211	100,718	5,494
1992	10,906	68,534	102,556	5,573
1993	10,929	69,355	103,469	5,561
1994	11,067	71,249	104,183	5,550
1995	11,209	72,978	105,622	5,545
1996	11,461	75,348	108,418	5,541
1997	11,506	78,805	109,820	5,541
1998	11,206	79,530	111,264	5,226
1999	10,793	80,715	112,223	4,987

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2000	10,471	82,230	113,406	4,826
2001	9,487	84,154	115,353	4,318
2002	9,272	86,334	121,210	5,077
2003	9,507	89,925	128,803	5,207
2004	9,732	94,959	135,478	5,339
2005	10,096	95,166	139,426	5,791
2006	10,232	95,184	147,632	5,427
2007	11,112	98,022	152,475	6,310
2008	10,687	97,668	150,789	6,339
2009	10,113	98,320	152,875	6,554
2010	9,180	97,947	150,456	5,583
2011	9,180	97,885	150,526	5,583
2012	9,180	97,901	150,436	5,583
2013	8,613	97,725	151,193	5,593
2014	8,613	97,725	151,193	5,593
2015	8,613	97,725	151,193	5,593
2016	8,613	97,725	151,193	5,593
2017	8,613	98,291	151,221	5,593
2018	8,613	98,291	151,221	5,593
2019	8,613	98,291	151,221	5,593
2020	8,613	98,291	151,221	5,593
2021	8,613	98,291	151,221	5,593
2022	8,613	98,291	151,221	5,593
2023	8,613	98,291	151,262	5,593
2024	8,613	98,291	151,262	5,593
2025	8,613	98,291	151,262	5,593
2026	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2000	10,471	82,230	113,406	4,826
2001	9,487	84,154	115,353	4,318
2002	9,272	86,334	121,210	5,077
2003	9,507	89,925	128,803	5,207
2004	9,732	94,959	135,478	5,339
2005	10,096	95,166	139,426	5,791
2006	10,232	95,779	147,632	5,427
2007	11,112	98,617	152,503	6,310
2008	10,687	98,263	150,816	6,339
2009	10,113	98,915	152,903	6,554
2010	9,180	98,543	150,483	5,583
2011	9,180	98,480	150,553	5,583
2012	9,180	98,467	150,504	5,583
2013	8,613	98,291	151,262	5,593
2014	8,613	98,291	151,262	5,593
2015	8,613	98,291	151,262	5,593
2016	8,613	98,291	151,262	5,593
2017	8,613	98,291	151,262	5,593
2018	8,613	98,291	151,262	5,593
2019	8,613	98,291	151,262	5,593
2020	8,613	98,291	151,262	5,593
2021	8,613	98,291	151,262	5,593
2022	8,613	98,291	151,262	5,593
2023	8,613	98,291	151,262	5,593
2024	8,613	98,291	151,262	5,593
2025	8,613	98,291	151,262	5,593
2026	8,613	98,291	151,262	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2027	8,613	98,291	151,262	5,593
2028	8,613	98,291	151,262	5,593
2029	8,613	98,291	151,262	5,593
2030	8,613	98,291	151,262	5,593
2031	8,613	98,291	151,262	5,593
2032	8,613	98,291	151,262	5,593
2033	8,613	98,291	151,262	5,593
2034	8,613	98,291	151,262	5,593
2035	8,613	98,291	151,262	5,593
2036	8,613	98,291	151,262	5,593
2037	8,613	98,291	151,262	5,593
2038	8,613	98,291	151,262	5,593
2039	8,613	98,291	151,262	5,593
2040	8,613	98,291	151,262	5,593
2041	8,613	98,291	151,262	5,593
2042	8,613	98,291	151,262	5,593
2043	8,613	98,291	151,262	5,593
2044	8,613	98,291	151,262	5,593
2045	8,613	98,291	151,262	5,593
2046	8,613	98,291	151,262	5,593
2047	8,613	98,291	151,262	5,593
2048	8,613	98,291	151,262	5,593
2049	8,613	98,291	151,262	5,593
2050	8,613	98,291	151,262	5,593
2051	8,613	98,291	151,262	5,593
2052	8,613	98,291	151,262	5,593
2053	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2027	8,613	98,291	151,262	5,593
2028	8,613	98,291	151,262	5,593
2029	8,613	98,291	151,262	5,593
2030	8,613	98,291	151,262	5,593
2031	8,613	98,291	151,262	5,593
2032	8,613	98,291	151,262	5,593
2033	8,613	98,291	151,262	5,593
2034	8,613	98,291	151,262	5,593
2035	8,613	98,291	151,262	5,593
2036	8,613	98,291	151,262	5,593
2037	8,613	98,291	151,262	5,593
2038	8,613	98,291	151,262	5,593
2039	8,613	98,291	151,262	5,593
2040	8,613	98,291	151,262	5,593
2041	8,613	98,291	151,262	5,593
2042	8,613	98,291	151,262	5,593
2043	8,613	98,291	151,262	5,593
2044	8,613	98,291	151,262	5,593
2045	8,613	98,291	151,262	5,593
2046	8,613	98,291	151,262	5,593
2047	8,613	98,291	151,262	5,593
2048	8,613	98,291	151,262	5,593
2049	8,613	98,291	151,262	5,593
2050	8,613	98,291	151,262	5,593
2051	8,613	98,291	151,262	5,593
2052	8,613	98,291	151,262	5,593
2053	8,613	98,291	151,262	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2054	8,613	98,291	151,262	5,593
2055	8,613	98,291	151,262	5,593
2056	8,613	98,291	151,262	5,593
2057	8,613	98,291	151,262	5,593
2058	8,613	98,291	151,262	5,593
2059	8,613	98,291	151,262	5,593
2060	8,613	98,291	151,262	5,593
2061	8,613	98,291	151,262	5,593
2062	8,613	98,291	151,262	5,593
2063	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2054	8,613	98,291	151,262	5,593
2055	8,613	98,291	151,262	5,593
2056	8,613	98,291	151,262	5,593
2057	8,613	98,291	151,262	5,593
2058	8,613	98,291	151,262	5,593
2059	8,613	98,291	151,262	5,593
2060	8,613	98,291	151,262	5,593
2061	8,613	98,291	151,262	5,593
2062	8,613	98,291	151,262	5,593
2063	8,613	98,291	151,262	5,593

*Due to the construct of the model, up to 132 groundwater acres in the TPNRD are located in cells classified as Logan County. This is caused by cell boundaries and legal boundaries not being congruent. The cell is the smallest unit of the model. Each cell was assigned a county designation by the location of the cell centroid. Even if a cell is bisected by the county boundary, the entire cell is assigned to one county. The same process was used to assign each cell an NRD designation.

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,818	8,263	140
1957	280	10,146	9,979	140
1958	237	10,757	11,654	140
1959	259	11,005	13,561	140
1960	280	12,094	13,907	140
1961	358	12,915	13,899	280
1962	365	13,965	14,224	280
1963	336	14,932	14,688	420
1964	330	15,801	14,834	420
1965	420	17,898	17,282	420
1966	399	19,714	19,328	420
1967	549	22,527	21,819	420
1968	790	24,513	23,841	700
1969	1,042	26,573	25,977	840
1970	1,165	28,357	31,009	980
1971	1,581	29,789	35,502	980
1972	1,465	31,546	40,067	980
1973	1,607	33,154	45,177	1,260
1974	1,907	34,313	49,581	1,540
1975	2,517	39,056	56,459	1,540

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,818	8,263	140
1957	280	10,146	9,979	140
1958	237	10,757	11,654	140
1959	259	11,005	13,561	140
1960	280	12,094	13,907	140
1961	358	12,915	13,899	280
1962	365	13,965	14,224	280
1963	336	14,932	14,688	420
1964	330	15,801	14,834	420
1965	420	17,898	17,282	420
1966	399	19,714	19,328	420
1967	549	22,527	21,819	420
1968	790	24,513	23,841	700
1969	1,042	26,573	25,977	840
1970	1,165	28,357	31,009	980
1971	1,581	29,789	35,502	980
1972	1,465	31,546	40,067	980
1973	1,607	33,154	45,177	1,260
1974	1,907	34,313	49,581	1,540
1975	2,517	39,056	56,459	1,540

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1976	2,648	44,393	61,489	1,540
1977	3,492	50,259	67,666	1,820
1978	4,857	55,248	73,851	2,940
1979	5,193	57,314	75,932	3,560
1980	6,067	59,598	79,123	4,158
1981	6,841	62,163	80,738	4,387
1982	7,188	64,269	82,255	4,746
1983	7,149	63,644	81,798	4,972
1984	7,267	63,585	79,110	5,350
1985	9,901	56,403	90,075	4,987
1986	9,918	56,495	89,710	5,094
1987	10,096	56,326	89,000	5,263
1988	10,118	57,462	89,449	5,323
1989	10,227	59,711	90,637	5,380
1990	10,247	61,259	91,808	5,438
1991	10,268	62,572	92,572	5,494
1992	10,305	63,804	94,330	5,573
1993	10,326	64,581	95,231	5,561
1994	10,464	66,004	95,934	5,550
1995	10,605	67,724	97,373	5,545
1996	10,857	69,868	100,180	5,541
1997	10,899	72,742	101,466	5,541
1998	10,618	73,239	102,532	5,226
1999	10,227	74,435	103,200	4,987
2000	9,934	75,965	104,291	4,826
2001	9,000	77,152	105,988	4,318

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1976	2,648	44,393	61,489	1,540
1977	3,492	50,259	67,666	1,820
1978	4,857	55,248	73,851	2,940
1979	5,193	57,314	75,932	3,560
1980	6,067	59,598	79,123	4,158
1981	6,841	62,163	80,738	4,387
1982	7,188	64,269	82,255	4,746
1983	7,149	63,644	81,798	4,972
1984	7,267	63,585	79,110	5,350
1985	9,901	56,403	90,075	4,987
1986	9,918	56,495	89,710	5,094
1987	10,096	56,326	89,000	5,263
1988	10,118	57,462	89,449	5,323
1989	10,227	59,711	90,637	5,380
1990	10,247	61,259	91,808	5,438
1991	10,268	62,572	92,572	5,494
1992	10,305	63,804	94,330	5,573
1993	10,326	64,581	95,231	5,561
1994	10,464	66,004	95,934	5,550
1995	10,605	67,724	97,373	5,545
1996	10,857	69,868	100,180	5,541
1997	10,899	72,742	101,466	5,541
1998	10,618	73,239	102,532	5,226
1999	10,227	74,435	103,200	4,987
2000	9,934	75,965	104,291	4,826
2001	9,000	77,152	105,988	4,318

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2002	8,796	79,165	111,189	5,077
2003	9,018	82,477	118,006	5,207
2004	9,232	87,078	124,383	5,339
2005	9,577	87,274	128,022	5,791
2006	9,784	86,962	134,677	5,427
2007	10,646	89,800	139,541	6,310
2008	10,296	89,452	137,752	6,339
2009	9,599	90,077	140,367	6,554
2010	8,722	89,812	137,454	5,583
2011	8,722	89,740	137,524	5,583
2012	8,722	89,756	137,434	5,583
2013	8,155	89,580	138,005	5,593
2014	8,155	89,580	138,005	5,593
2015	8,155	89,580	138,005	5,593
2016	8,155	89,580	138,005	5,593
2017	8,155	90,146	138,032	5,593
2018	8,155	90,146	138,032	5,593
2019	8,155	90,146	138,032	5,593
2020	8,155	90,146	138,032	5,593
2021	8,155	90,146	138,032	5,593
2022	8,155	90,146	138,032	5,593
2023	8,155	90,146	138,073	5,593
2024	8,155	90,146	138,073	5,593
2025	8,155	90,146	138,073	5,593
2026	8,155	90,146	138,073	5,593
2027	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2002	8,796	79,165	111,189	5,077
2003	9,018	82,477	118,006	5,207
2004	9,232	87,078	124,383	5,339
2005	9,577	87,274	128,022	5,791
2006	9,784	87,557	134,677	5,427
2007	10,646	90,395	139,568	6,310
2008	10,296	90,047	137,779	6,339
2009	9,599	90,672	140,394	6,554
2010	8,722	90,407	137,481	5,583
2011	8,722	90,335	137,551	5,583
2012	8,722	90,322	137,502	5,583
2013	8,155	90,146	138,073	5,593
2014	8,155	90,146	138,073	5,593
2015	8,155	90,146	138,073	5,593
2016	8,155	90,146	138,073	5,593
2017	8,155	90,146	138,073	5,593
2018	8,155	90,146	138,073	5,593
2019	8,155	90,146	138,073	5,593
2020	8,155	90,146	138,073	5,593
2021	8,155	90,146	138,073	5,593
2022	8,155	90,146	138,073	5,593
2023	8,155	90,146	138,073	5,593
2024	8,155	90,146	138,073	5,593
2025	8,155	90,146	138,073	5,593
2026	8,155	90,146	138,073	5,593
2027	8,155	90,146	138,073	5,593

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2028	8,155	90,146	138,073	5,593
2029	8,155	90,146	138,073	5,593
2030	8,155	90,146	138,073	5,593
2031	8,155	90,146	138,073	5,593
2032	8,155	90,146	138,073	5,593
2033	8,155	90,146	138,073	5,593
2034	8,155	90,146	138,073	5,593
2035	8,155	90,146	138,073	5,593
2036	8,155	90,146	138,073	5,593
2037	8,155	90,146	138,073	5,593
2038	8,155	90,146	138,073	5,593
2039	8,155	90,146	138,073	5,593
2040	8,155	90,146	138,073	5,593
2041	8,155	90,146	138,073	5,593
2042	8,155	90,146	138,073	5,593
2043	8,155	90,146	138,073	5,593
2044	8,155	90,146	138,073	5,593
2045	8,155	90,146	138,073	5,593
2046	8,155	90,146	138,073	5,593
2047	8,155	90,146	138,073	5,593
2048	8,155	90,146	138,073	5,593
2049	8,155	90,146	138,073	5,593
2050	8,155	90,146	138,073	5,593
2051	8,155	90,146	138,073	5,593
2052	8,155	90,146	138,073	5,593
2053	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2028	8,155	90,146	138,073	5,593
2029	8,155	90,146	138,073	5,593
2030	8,155	90,146	138,073	5,593
2031	8,155	90,146	138,073	5,593
2032	8,155	90,146	138,073	5,593
2033	8,155	90,146	138,073	5,593
2034	8,155	90,146	138,073	5,593
2035	8,155	90,146	138,073	5,593
2036	8,155	90,146	138,073	5,593
2037	8,155	90,146	138,073	5,593
2038	8,155	90,146	138,073	5,593
2039	8,155	90,146	138,073	5,593
2040	8,155	90,146	138,073	5,593
2041	8,155	90,146	138,073	5,593
2042	8,155	90,146	138,073	5,593
2043	8,155	90,146	138,073	5,593
2044	8,155	90,146	138,073	5,593
2045	8,155	90,146	138,073	5,593
2046	8,155	90,146	138,073	5,593
2047	8,155	90,146	138,073	5,593
2048	8,155	90,146	138,073	5,593
2049	8,155	90,146	138,073	5,593
2050	8,155	90,146	138,073	5,593
2051	8,155	90,146	138,073	5,593
2052	8,155	90,146	138,073	5,593
2053	8,155	90,146	138,073	5,593

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2054	8,155	90,146	138,073	5,593
2055	8,155	90,146	138,073	5,593
2056	8,155	90,146	138,073	5,593
2057	8,155	90,146	138,073	5,593
2058	8,155	90,146	138,073	5,593
2059	8,155	90,146	138,073	5,593
2060	8,155	90,146	138,073	5,593
2061	8,155	90,146	138,073	5,593
2062	8,155	90,146	138,073	5,593
2063	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2054	8,155	90,146	138,073	5,593
2055	8,155	90,146	138,073	5,593
2056	8,155	90,146	138,073	5,593
2057	8,155	90,146	138,073	5,593
2058	8,155	90,146	138,073	5,593
2059	8,155	90,146	138,073	5,593
2060	8,155	90,146	138,073	5,593
2061	8,155	90,146	138,073	5,593
2062	8,155	90,146	138,073	5,593
2063	8,155	90,146	138,073	5,593

A.1.6 North Dry Creek pumping data excel spreadsheet

NWNE 27-8N-16W

NAD 8 Lat: N40 38' 25.91700"

Surface Elev: 2156.92'

Augmentation Production Well

Long: W99 06' 59.91771"

G-159762 Well ID: 210850

Stickup: 2.25'

Start Date / Time	End Date Time	MP Depth	Stickup	Depth	Elevation	Begin Meter	End Meter	Ac/In Pumped Interval	Ac/In Annual Total	Pumping Rate GPM	Gallons Pumped Interval	Annual Total Gallons	Comments
7/12/2011 15:00	7/12/2011 15:00	M	2.25			0.00	0.31	0.31		1275			Well Contractor Pumped Well
7/13/2011 10:40	7/13/2011 11:00	M	2.25			0.31	1.21	0.90		1250			Started Well @ 10:40--No SWL--Access Blocked
7/13/2011 11:00	7/13/2011 11:20	23.13	2.25	20.88	2136.04	1.21	2.12	0.91		1250			Observed No Irrigation Wells Running In Local Area
7/13/2011 11:20	7/13/2011 11:40	23.25	2.25	21.00	2135.92	2.12	3.03	0.91		1240			Well Contractor Removed Blockage From Access Port
7/13/2011 11:40	7/13/2011 12:00	23.28	2.25	21.03	2135.89	3.03	3.92	0.89		1240			
7/13/2011 12:00	7/13/2011 12:20	23.44	2.25	21.19	2135.73	3.92	4.84	0.92		1240			
7/13/2011 12:20	7/13/2011 12:40	23.51	2.25	21.26	2135.66	4.84	5.70	0.86		1240			
7/13/2011 12:40	7/13/2011 13:00	23.56	2.25	21.31	2135.61	5.70	6.61	0.91		1240			
7/13/2011 13:00	7/13/2011 13:20	23.62	2.25	21.37	2135.55	6.61	7.58	0.97		1240			Discharge Water Temp 52 F / 11 C
7/13/2011 13:20	7/13/2011 13:40	23.69	2.25	21.44	2135.48	7.58	8.40	0.82		1240			
7/13/2011 13:40	7/13/2011 14:00	23.72	2.25	21.47	2135.45	8.40	9.32	0.92		1240			Stopped Well @ 14:00--9.01 A/I Pumped 7/13/2011
7/13/2011 14:00	7/13/2011 14:10	8.56	2.25	6.31	2150.61	9.32	9.32	0.00		0			
7/13/2011 14:10	7/13/2011 14:20	8.39	2.25	6.14	2150.78	9.32	9.32	0.00		0			
7/13/2011 14:20	7/13/2011 14:30	8.24	2.25	5.99	2150.93	9.32	9.32	0.00		0			
7/13/2011 14:30	7/13/2011 14:40	8.12	2.25	5.87	2151.05	9.32	9.32	0.00		0			
7/13/2011 14:40	7/13/2011 15:00	7.92	2.25	5.67	2151.25	9.32	9.32	0.00		0			
7/13/2011 15:00	7/13/2011 15:30	7.67	2.25	5.42	2151.50	9.32	9.32	0.00		0			
7/14/2011 13:20		7.07	2.25	4.82	2152.10	9.32	9.32	0.00		0			1/2 Pivot @ W1/2NW1/4 & Pivot @ SE1/4 Running
7/20/2011 13:20		7.40	2.25	5.15	2151.77	9.32	9.32	0.00		0			
8/5/2011 13:10		8.04	2.25	5.79	2151.13	9.32	9.32	0.00		0			Nitrate Sample=28.4 ppm
10/24/2011 12:00		7.61	2.25	5.36	2151.56	9.32	18.39	9.07	**18.39**	1200		**499,362**	Well Ran During The Month Of October--JT
3/12/2012 11:45		7.67	2.25	5.42	2151.50	18.39	18.39	0.00	0.00	0	0	0	Water Meter Reading @ 11:45--0018.39 A/I
5/11/2012 12:00		7.54	2.25	5.29	2151.63	18.39	18.39	0.00	0.00	0	0	0	Water Meter Reading @ 12:00--0018.39 A/I
6/6/2012 14:25		7.72	2.25	5.47	2151.45	18.39	18.45	0.06	0.06	1200	1,629	1,629	Water Meter Reading @ 14:30--0018.45 A/I--Well In SW1/4 Sec 26 Running
6/7/2012 13:10	6/7/2012 13:15	7.76	2.25	5.51	2151.41	18.45	18.52	0.07	0.13	1200	1,901	3,530	Water Meter Reading @ 13:10--Well In SW1/4 Sec 26 OFF / Well In NW1/4 Sec 26 Running
6/7/2012 13:15	6/7/2012 13:30	21.94	2.25	19.69	2137.23	18.52	19.01	0.49	0.62	1200	13,305	16,835	Started Augmentation Well @ 13:15
6/7/2012 13:30	6/7/2012 13:45	22.15	2.25	19.90	2137.02	19.01	19.66	0.65	1.27	1200	17,650	34,486	
6/7/2012 13:45	6/7/2012 14:00	22.28	2.25	20.03	2136.89	19.66	20.31	0.65	1.92	1200	17,650	52,136	
6/7/2012 14:00	6/7/2012 14:15	22.36	2.25	20.11	2136.81	20.31	20.94	0.63	2.55	1200	17,107	69,243	
6/7/2012 14:15	6/7/2012 14:30	22.47	2.25	20.22	2136.70	20.94	21.59	0.65	3.20	1200	17,650	86,893	Discharge Water Temp 52 F / 11 C--N40 38' 25.80" / W099 06' 58.40" Elev ~2158' RH
6/7/2012 14:30	6/7/2012 14:45	22.55	2.25	20.30	2136.62	21.59	22.26	0.67	3.87	1200	18,193	105,086	
6/7/2012 14:45	6/7/2012 15:00	22.62	2.25	20.37	2136.55	22.26	22.90	0.64	4.51	1200	17,379	122,465	
6/7/2012 15:00	6/7/2012 15:15	22.68	2.25	20.43	2136.49	22.90	23.58	0.68	5.19	1200	18,465	140,929	
6/7/2012 15:15	6/7/2012 15:30	22.72	2.25	20.47	2136.45	23.58	24.19	0.61	5.80	1200	16,564	157,493	
6/7/2012 15:30	6/7/2012 15:45	22.74	2.25	20.49	2136.43	24.19	24.86	0.67	6.47	1200	18,193	175,686	Last Measurement For 6/7/2012--Well Still Running

6/7/2012 15:45	6/8/2012 9:00	23.93	2.25	21.68	2135.24	24.86	68.97	44.11	50.58	1190	1,197,763	1,373,449	Started Nickel Pivot Well @ 10:00
6/8/2012 9:00	6/8/2012 10:15	23.98	2.25	21.73	2135.19	68.97	72.33	3.36	53.94	1190	91,237	1,464,687	Discharge Water Temp 52 F / 11 C
6/8/2012 10:15	6/8/2012 11:00	23.98	2.25	21.73	2135.19	72.33	74.30	1.97	55.91	1190	53,493	1,518,180	
6/8/2012 11:00	6/8/2012 14:15	24.07	2.25	21.82	2135.10	74.30	82.50	8.20	64.11	1190	222,663	1,740,843	Started Nickel Gravity Well @ 13:15
6/8/2012 14:15	6/8/2012 15:45	24.10	2.25	21.85	2135.07	82.50	86.35	3.85	67.96	1190	104,543	1,845,386	Last Measurement For 6/8/2012--Well Still Running
6/8/2012 15:45	6/11/2012 15:50	24.78	2.25	22.53	2134.39	86.35					0	0	Gravity Well OFF / Pivot Well Running / No Meter Reading
6/11/2012 15:50		24.78	2.25	22.53	2134.39	86.35					0	0	Wells In E1/2 Sec 27 Running
6/11/2012 15:50	6/15/2012 11:45	25.24	2.25	22.99	2133.93	86.35	503.68	417.33	485.29	1180	11,332,179	13,177,565	Wells In E1/2 Sec 27 Running--Well In NW1/4 Sec 26 Running--Gravity Well OFF
6/15/2012 11:45	6/18/2012 15:00	25.30	2.25	23.05	2133.87	503.68	695.02	191.34	676.63	1190	5,195,646	18,373,211	Wells in E1/3 Sec 27 Running--Gravity Well Running--Augmentation Well Running
6/18/2012 15:00	6/18/2012 15:10	25.30	2.25	23.05	2133.87	695.02	695.43	0.41	677.04	1190	11,133	18,384,344	Wells in E1/3 Sec 27 Running--Gravity Well Running--Augmentation Well Running
6/18/2012 15:10	6/18/2012 15:15	25.30	2.25	23.05	2133.87	695.43	695.63	0.20	677.24	1190	5,431	18,389,775	Wells in E1/3 Sec 27 Running--Gravity Well Running--Augmentation Well Running
6/18/2012 15:15	6/18/2012 16:00	25.30	2.25	23.05	2133.87	695.63	697.54	1.91	679.15	1190	51,864	18,441,639	Wells in E1/3 Sec 27 Running--Gravity Well Running--Augmentation Well Running
6/18/2012 16:00	6/21/2012 12:30	25.48	2.25	23.23	2133.69	697.54	871.30	173.76	852.91	1180	4,718,279	23,159,918	Gravity, Pivot, Augmentation Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 12:30	6/21/2012 13:00	25.48	2.25	23.23	2133.69	871.30	872.56	1.26	854.17	1180	34,214	23,194,132	Gravity, Pivot, Augmentation Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:00	6/21/2012 13:15	25.48	2.25	23.23	2133.69	872.56	873.21	0.65	854.82	1180	17,650	23,211,782	Gravity, Pivot, Augmentation Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:15	6/21/2012 13:16	25.48	2.25	23.23	2133.69	873.21	873.24	0.03	854.85	1180	815	23,212,597	Augmentation Well OFF @ 13:16
6/21/2012 13:16	6/21/2012 13:21	12.16	2.25	9.91	2147.01	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:21	6/21/2012 13:26	12.04	2.25	9.79	2147.13	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:26	6/21/2012 13:30	11.96	2.25	9.71	2147.21	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:30	6/21/2012 13:45	11.70	2.25	9.45	2147.47	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:45	6/21/2012 14:00	11.52	2.25	9.27	2147.65	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 14:00	6/21/2012 14:30	11.42	2.25	9.17	2147.75	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Well in NW1/4 Sec 27 OFF, SW1/4 Sec 26 Running

6/21/2012 14:30	6/21/2012 15:00	11.04	2.25	8.79	2148.13	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Well in NW1/4 Sec 27 OFF, SW1/4 Sec 26 Running
6/21/2012 15:00	6/21/2012 15:30	10.85	2.25	8.60	2148.32	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Well in NW1/4 Sec 27 OFF, SW1/4 Sec 26 Running
6/21/2012 15:30	6/21/2012 15:45	10.77	2.25	8.52	2148.40	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Well in NW1/4 Sec 27 OFF, SW1/4 Sec 26 Running
6/21/2012 15:45	6/22/2012 10:40	9.31	2.25	7.06	2149.86	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Wells in NW1/4, SW1/4 Sec 26 Running, Well in SE1/4 Sec 27 Running
6/25/2012 13:05		8.67	2.25	6.42	2150.50	873.24	873.24	0.00	854.85	0	0	23,212,597	Gravity OFF, Augmentation Well OFF, Pivot OFF / Wells in SW1/4 Sec 26 Running, SE1/4 Sec 27 Running / Loggers Returned To 12-Hour Readings
8/30/2012		[redacted]			2146.67	873.24	4038.93	3165.69	4020.54	1175	85,961,146	109,173,743	Augmentation Well running, Pivot Running, Gravity Off
9/5/2012		[redacted]			2146.67	4038.93	4405.50	366.57	4387.11	1175	9,953,842	119,127,585	Augmentation Well running, Pivot Off, Gravity Off
9/6/2012		[redacted]			2146.17	4405.50	4464.20	58.70	4445.81	1175	1,593,940	120,721,525	Augmentation Well running, Pivot Off, Gravity Off
9/7/2012		[redacted]			2146.17	4464.20	4511.65	47.45	4493.26	1150	1,288,457	122,009,982	Augmentation Well OFF @ 9:29 AM
9/11/2012		11.56	2.25	9.31	2147.61	4511.65	4511.65	0.00	4493.26	0	0	122,009,982	Augmentation Well OFF, Creek Dry
9/17/2012		11.28	2.25	9.03	2147.89	4511.65	4511.65	0.00	4493.26	0	0	122,009,982	Augmentation Well OFF, Creek Dry
10/22/2012		10.61	2.25	8.36	2148.56	4511.65	4511.65	0.00	**4493.26**	0	0	**122,009,982**	Augmentation Well OFF, Creek Dry, Pivot off, Gravity on livestock, Well in SW1/4 Sec 26 Running
5/10/2013		8.50	2.25	6.25	2150.67	4511.65	4511.65	0.00	0.00		0	0	Augmentation Well OFF - started at 11:00. SE 27 pivot dripping, Other wells off, Nickel wells off
5/20/2013		10.81	2.25	8.56	2148.36	4511.65	5005.05	493.40	493.40	1200	13,397,784	13,397,784	Augmentation Well ON, Gravity Off, Pivot Off (12 Hr cycle)
5/30/2013		9.16	2.25	6.91	2150.01	5005.05	5305.77	300.72	794.12	0	8,165,751	21,563,534	All Wells OFF (12 Hr cycle)
6/6/2013		9.67	2.25	7.42	2149.50	5305.77	5529.03	223.26	1017.38	0	6,062,402	27,625,937	All Wells OFF (12 Hr cycle)
6/13/2013		10.08	2.25	7.83	2149.09	5529.00	5750.02	221.02	1238.40	0	6,001,577	33,627,514	All Wells OFF (12 Hr cycle)
7/5/2013		11.72	2.25	9.47	2147.45	5750.02	6391.70	641.68	1880.08	0	17,424,179	51,051,692	Augmentation Well Off, All Wells Pumping
7/16/2013		11.75	2.25	9.50	2147.42	6391.70	6711.23	319.53	2199.61	0	8,676,518	59,728,210	Augmentation Well Off, Creek Dry, All Wells Pumping
7/25/2013		10.92	2.25	8.67	2148.25	6711.23	6711.23	0.00	2199.61	0	0	59,728,210	Augmentation Well Off, Beginning Flow in Creek, Nickel Pivot Off, All other surrounding wells running
7/31/2013		10.51	2.25	8.26	2148.66	6711.23	6711.23	0.00	2199.61	0	0	59,728,210	Augmentation Well Off, Creek Flowing @ Outlet, Not flowing at River Road, Gravity Off, Pivot Running
8/7/2013		13.17	2.25	10.92	2146.00	6711.23	6929.92	218.69	2418.30	0	5,938,308	65,666,518	Augmentation Well Off, Creek Flowing
8/21/2013		13.00	2.25	10.75	2146.17	6929.92	7498.93	569.01	2987.31	0	15,450,898	81,117,416	Augmentation Well Off, Creek Flowing
8/29/2013		11.72	2.25	9.47	2147.45	7498.93	7762.48	263.55	3250.86	0	7,156,437	88,273,852	Augmentation Well Off, No Flow in Creek
9/6/2013		11.45	2.25	9.20	2147.72	7762.48	7762.48	0.00	3250.86	0	0	88,273,852	Augmentation Well Off, No Flow in Creek

9/17/2013	11.80	2.25	9.55	2147.37	7762.48	7762.48	0.00	3250.86	0	0	88,273,852	Augmentation Well Off, No Flow in Creek
11/7/2013	9.53	2.25	7.28	2149.64	7762.48	7762.48	0.00	**3250.86**	0	0	**88,273,852**	Augmentation Well Off, No Flow in Creek

A.1.7 Memorandums on the Calculations of Excess Flows, Recharge Volumes and Percentages, and Discharge Volumes for Canal Recharge

March 15, 2018
rev. June 12, 2018 and June 7, 2019

To: The Platte Overappropriated Area Committee Technical Committee
From: Margeaux Carter and Kari Burgert, Nebraska Department of Natural Resources
Date: March 15, 2018, revised June 12, 2018, revised June 7, 2019
Re: Data Sourcing and Summary of Diversion of Excess Flows for Canal Recharge

Summary
The accepted various diversions of excess flow for canal recharge have been combined into a single file with daily discharge rates for each canal with excess flow for 2011, 2012, and 2013. The final discharge data file is "POAC_2011_2013_FINAL.xlsx."

This memo will list the data sources for the excess flow data which will be used to assess the effectiveness of artificial recharge and streamflow augmentation projects in the Robust Review. The diversion periods described in the 10/26/2017 memo from Tracy Zayac "Memo to POAC Admins on canal recharge for RR rev10262017.pdf" (Zayac memo) are used for the analysis. The records of the diversion period from the sources described in this memo may vary from those described in the Zayac memo. The periods of diversion chosen in the Zayac memo considered information additional to diversion records, including contracts, irrigation season, and other records from the time of the excess flow diversion. The canal diversion sources used for this analysis may have been updated since the memo causing slight variations in the diversion periods.

Data Sources for Excess Flow Diversions
Listed in Table 1 are the canals for which the NeDNR streamgaging website was used to obtain discharge data during periods of excess flow from 2011 to 2013. The canals are listed by their name in the Zayac memo with their stream gage name and number in the NeDNR stream gaging list and index (https://nednr.nebraska.gov/RealTime/Gage/Index). Note that Farmers canal is referred to as "Tri-State Canal" and Pathfinder as "Interstate Canal" in the NeDNR Gage Index. According to the Zayac memo, Winters Canal excess flow dates apply to the combined discharge between the "Winters Canal from Winters Creek" and "Winters Canal from North Platte River". These values have been combined in the final excess flow datasheet, but it should be noted that the discharge recorded in Winters Canal from North Platte River during the accepted excess flow dates was zero. Lateral E65 discharge is not available in the NeDNR database. Pathfinder discharge data prior to 2012 and Lisco data between 4/13/2011 and 10/1/2011 are not digitized in the NeDNR streamgaging website and can be found in the annual NeDNR Hydrographic reports. The NeDNR Hydrographic report originally obtained for Pathfinder for this study reported on United States Bureau of Reclamation (USBR) measurements that had since been updated by the USBR. The diversions on Pathfinder Canal used in this study were obtained from the USBR Hydromet website on May 2018.

Table 1. Canals with excess flow between 2011 and 2013 obtained from NeDNR streamgaging database and the canal gage name and number

Canal	NeDNR Gage Name	Gage Number
Belmont	Belmont Canal from North Platte River	9000
Castle Rock	Castle Rock-Steamboat Canal from North Platte River	21000
Central	Central Canal from North Platte River	22000
Chimney Rock	Chimney Rock Canal from North Platte River	24000
Cozad	Cozad Canal from Platte River	33000
Dawson County	Dawson County Canal from Platte River	37000
Enterprise	Enterprise Canal from North Platte River	40000
Farmer’s	Tri-State Canal from North Platte	145100
Gothenburg	Gothenburg Canal from Platte River	57000
Kearney	Kearney Canal from Platte River	73000
Keith Lincoln	Keith-Lincoln County Canal from North Platte River	76000
Lisco	Lisco Canal from North Platte River	8200
Minatare	Minatare Canal from North Platte River	99000
Nine Mile	Ninemile Canal from North Platte River	106000
North Platte	North Platte Canal from North Platte River	114000
Orchard-Alfalfa	Orchard-Alfalfa Canal from Platte River	117000
Paxton Hershey	Paxton-Hershey Canal from North Platter	121000
Suburban	Suburban Canal from North Platte River	136000
Thirty Mile	Thirty Mile Canal from Platte River	141000
Western	Western Canal from South Platte River	147000
Winters	Winters Creek Canal from North Platte River	148000
Winters	Winters Creek Canal from Winters Creek	149000

Listed in Table 2 are the data sources for excess flow canal discharge not found in the NeDNR streamgaging database. Daily discharge data for Dawson County and Thirty Mile canals in the fall of 2013 were available in the interactive NeDNR streamgaging database and were corroborated with external data provided in Table 2. Daily discharge data for Lisco canals was available in the Hydrographic reports and also corroborated with externally obtained data provided in Table 2. Digitized discharge data was available for 23 days of Lisco canal’s excess flow period in the fall of 2011. Discharge data for E65 Canal and Phelps Canal were provided entirely by CNPPID.

Table 2. Data sources for canal discharge not found in NeDNR gage database

Canal	Event	Data Source	Obtained
Lisco	Spring 2011	WISKI NeDNR, "2017-12-04Lisco.xlsx"	12/4/17
Pathfinder	Spring 2011	USBR Hydromet	May 2018
Lisco	Fall 2011	WISKI NeDNR, "2017-12-04Lisco.xlsx"	12/4/17
Dawson County	Fall 2013	NPPD, Jeff Shafer to NeDNR, Jessie Strom, "Dawson County Canal Diversion 2013-09-22 to 2013-10-09.xlsx"	3/13/17
E-65	Fall 2013	CNPPID , "Groundwater Recharge Diversions Summary 4-9-2018.xlsx"	4/9/18
Phelps	Fall 2013	CNPPID , "Groundwater Recharge Diversions Summary 4-9-2018.xlsx"	4/9/18
Thirty Mile	Fall 2013	CPNRD, Duane Woodward to NeDNR, Jessie Strom, "ThirtyMileexcess_Diversion_2013fall.xlsx"	2/21/17

To: The Platte Overappropriated Area Committee Technical Committee
From: Kari Burgert, Nebraska Department of Natural Resources
Date: June 14, 2018, updated October 11, 2018
Re: CPNRD, **TBNRD, and TPNRD Monthly Excess Flow Discharge Volumes, Recharge Percentages, Recharge Volumes, and Locations for the COHYST model**

This memo provides the final recharge volumes from excess flow diversions into Elwood Reservoir and excess flow canal diversions from 2011-2013 for Central Platte Natural Resources District (CPNRD), Tri-Basin Natural Resources District (TBNRD), and Twin Platte Natural Resources District (TPNRD) for use in the COHYST-area portion of the 2018 Robust Review. TPNRD and South Platte Natural Resources District excess flow diversions on Western Canal will be assessed with the Western Water Use Model.

Tables 1-3 have summaries of the monthly volumes of excess flow and resulting estimated recharge volumes for CPNRD, TBNRD, and TPNRD-contracted canal excess flows, respectively. Canal diversion volumes in this memorandum are from the POAC Technical Committee memorandum ExcessFlowData_SourceSummary.docx and associated data spreadsheet POAC_2011_2013.xlsx. Recharge percentages for all excess flow canal diversions except the Fall 2013 E65 diversions and CPNRD canals Cozad, Orchard-Alfalfa, and Thirty Mile were obtained from the spreadsheet PlatteRechargeDateComparison_For POAC_daw.xlsx. The methodology for calculating the recharge percentages in that spreadsheet was to assume recharge up to the rate modeled in the COHYST surface water operations model and average the percentage of the assumed recharge rates to the diversion rates over the period of excess flow diversion. This methodology was applied to the Fall 2013 E65 diversions, and 100% recharge was calculated. Recharge rates for Cozad, Orchard-Alfalfa, and Thirty Mile canals for these recharge events were obtained from CPNRD.

TBNRD contracted 50% of the Fall 2011 and Fall 2013 excess flow events on Phelps Canal; PRRIP contracted the remaining 50% of these events. The total recharge volumes for these events will be included in the model files, and benefits to the Platte Basin from TBNRD management will be calculated as 50% of the modeled accretions from these events. Inclusion of additional excess flow recharge events from Phelps and E65 are discussed in the July 17, 2018, NeDNR memo to the POAC Technical Committee Re: Phelps/E65 Canal Recharge Sensitivity (20180718_PhelpsE65_Sensititivy_Memo.docx).

Recharge from excess flow diversions into Elwood Reservoir were assumed to be 100% of the total pumped. For each excess flow event, all of the excess flow water pumped was assumed be recharged at a constant daily rate over 180 days starting with the first diversion date. The daily volumes pumped into Elwood Reservoir were obtained from the spreadsheet obtained from CNPPID, “CNPPID_Groundwater Recharge Diversions Summary 1-8-2016.xlsx.” A total of 44,730 acre-feet of excess flow were diverted to and recharged from Elwood Reservoir from 2006 to 2013. Table 4 provides the Elwood Reservoir diversion/recharge volumes per event. Shown in Figure 1 are the monthly diversion and recharge volumes for the Elwood Reservoir excess flow recharge projects for analysis in the 2018 Robust Review.

Figures of the model cell locations of recharge are also provided (Figures 2-4). The model cell locations for each canal were obtained from the COHYST model table StellaCanalToModflowGrid.csv used for assigning canal recharge from the surface water model to the groundwater model during integrated runs. The model cell locations for Elwood recharge were obtained from the COHYST model table StellaReservoirToModflowGrid.csv. Figure 2 shows the model cell locations of the CPNRD excess flow recharge events. Figure 3 presents the model cell locations of the TBNRD excess flow recharge events. The Phelps and E65 canal recharge locations were determined from the CNPPID groundwater recharge diversion summaries spreadsheets and the contracts for the events. The TBNRD Fall 2011 event occurred on Phelps canal to Mile Post 9.7. The TBNRD Fall 2013 event occurred on Phelps canal to Mile Post 13.3 (including the section to Mile Post 9.7) and on the E65 canal to Mile Post 23.7, on laterals to and within Cottonwood WPA, and on E65 to Mile Post 36.2S/Loomis. Figure 4 presents the model cell locations of the TPNRD excess flow recharge events. Spring and Fall 2011 excess flow events for TPNRD occurred on all four canals: Keith Lincoln, North Platte, Paxton Hershey, and Suburban. The TPNRD Fall 2013 events occurred on North Platte and Paxton Hershey.

Table 1. CPNRD-contracted monthly excess flow discharge volumes, recharge percentages, and recharge volumes

		Cozad			Orchard-Alfalfa			Thirty Mile		
Year	Month	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)
2011	4	833	0.85	708	144	0.85	122	1,192	0.60	715
2011	5	930	0.85	791	830	0.85	706	4,322	0.60	2,593
2011	9	877	0.85	745	1,010	0.85	858	4,760	0.60	2,856
2011	10	474	0.85	403	506	0.85	430	379	0.60	227
2012	3				78	0.85	66			
2013	9							3693	0.60	2,216
2013	10							3442	0.60	2,065
	Total	3,114		2,647	2,567		21,825	17,789		10,673

		Dawson County			Gothenburg			Kearney			Total
Year	Month	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)	Recharge (af)
2011	4	899	0.998	897	3,124	0.995	3,108	3074	0.286	879	6,430
2011	5	3,148	0.998	3,141	3,154	0.995	3,138	1216	0.286	348	10,717
2011	9	2,436	0.998	2,431	3,602	0.995	3,584				10,474
2011	10	1,018	0.998	1,015	2,126	0.995	2,116				4,191
2012	3										66
2013	9	932	1.000	932	1,481	0.985	1,458				4,607
2013	10	569	1.000	569	748	0.985	737				3,371
	Total	9,001		8,986	14,234		14,141	4,290		1,227	39,856

Table 2. TBNRD-contracted monthly excess flow canal discharge volumes, canal recharge percentages, and canal recharge volumes

		E65			Phelps				Total
Year	Month	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Contracted Fraction	Recharge (af)	Recharge (af)
2011	9				603	1.000	0.50	302	302
2011	10				1,828	1.000	0.50	914	914
2011	11				1,731	1.000	0.50	866	866
2011	12				1,257	1.000	0.50	629	629
2012	1				139	1.000	0.50	70	70
2013	9	1,341	1.000	1,341	1,821	0.981	0.50	893	2,234
2013	10	1,293	1.000	1,293	1,907	0.981	0.50	935	2,228
Total		2,634		2,634	9,286			4,608	7,242

Table 3. TPNRD-contracted monthly excess flow discharge volumes, recharge percentages, and recharge volumes

		Keith Lincoln			North Platte		
Year	Month	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)
2011	4	1,256	0.972	1,221	2,102	0.988	2,077
2011	5	1,012	0.972	983	2,557	0.988	2,526
2011	6	99	0.972	96			
2011	9	724	0.972	704	795	0.988	786
2011	10	1,315	0.972	1,278	3,582	0.988	3,539
2013	9				2,261	0.954	2,157
2013	10				1,248	0.954	1,191
	Total	4,406		4,283	12,546		12,276

		Paxton Hershey			Suburban			Total
Year	Month	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)	Recharge (af)
2011	4	982	0.969	951	925	1.000	925	5,175
2011	5	849	0.969	823	964	1.000	964	5,296
2011	6							96
2011	9	785	0.969	761	924	1.000	924	3,175
2011	10	1,554	0.969	1,505	839	1.000	839	7,162
2013	9	1,117	0.878	980				3,138
2013	10	667	0.878	585				1,776
	Total	5,953		5,606	3,652		3,652	25,818

Table 4. Diversion/recharge volumes per Elwood Reservoir excess flow recharge projects for analysis in the 2018 Robust Review.

Start Date of Elwood Recharge Diversions	End Date of Elwood Recharge Diversions	Diverted and Recharged Volume (acre-feet)
1/24/2006	2/13/2006	6,132
8/8/2006	8/10/2006	627
12/22/2006	12/31/2006	2,793
5/30/2007	6/25/2007	7,262
7/9/2007	7/11/2007	419
7/31/2007	8/8/2007	2,277
5/23/2008	6/11/2008	6,963
7/18/2008	7/21/2008	1,169
8/10/2008	8/19/2008	1,193
6/21/2009	8/21/2009	2,906
9/19/2013	10/31/2013	12,989

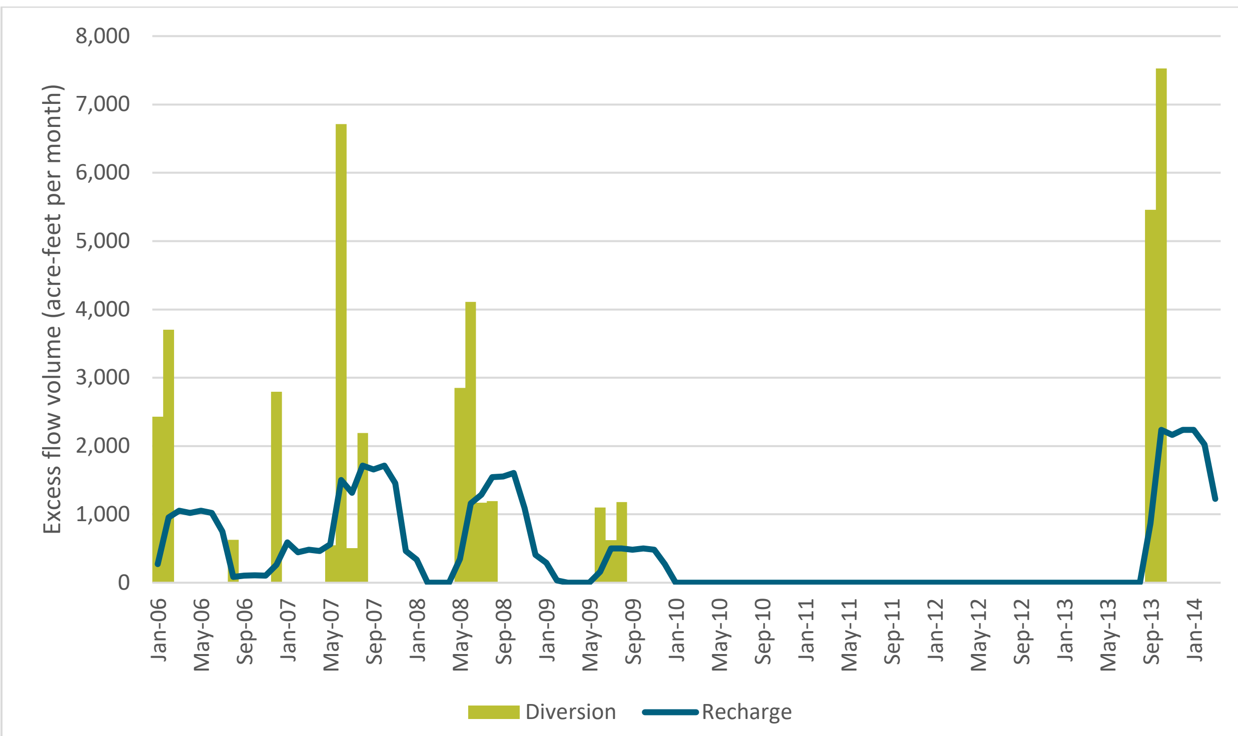

Figure 1. Excess flow monthly volumes pumped into and monthly volumes of excess flow water recharged from Elwood Reservoir.

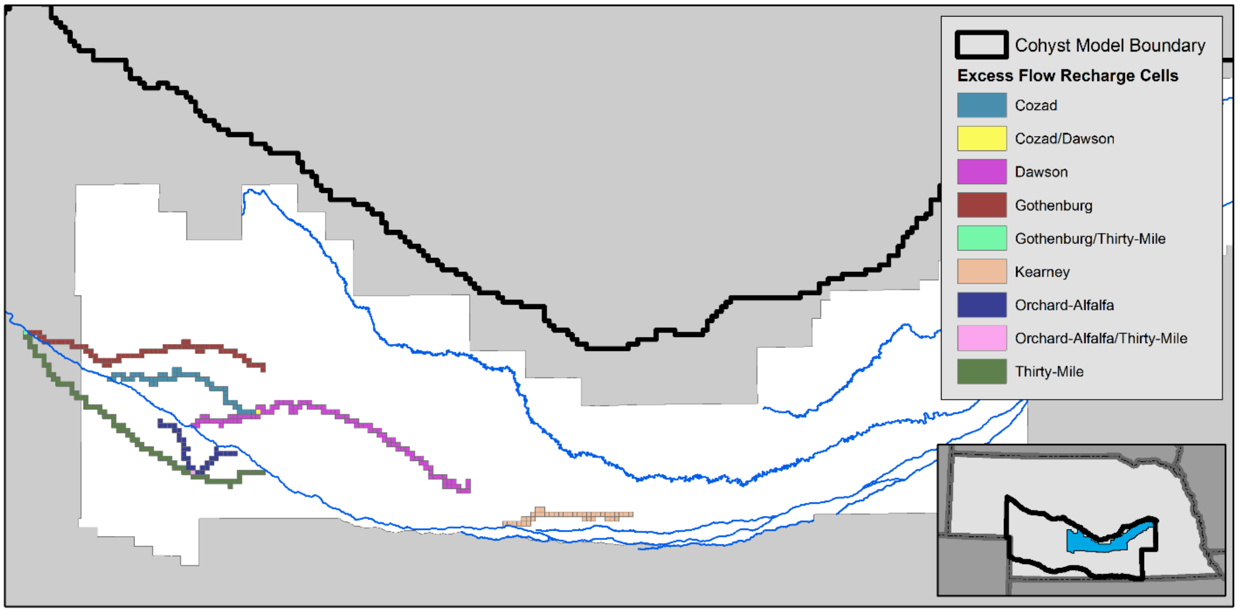

Figure 2. Model cell locations for the CPNRD excess flow recharge events within the COHYST model area.

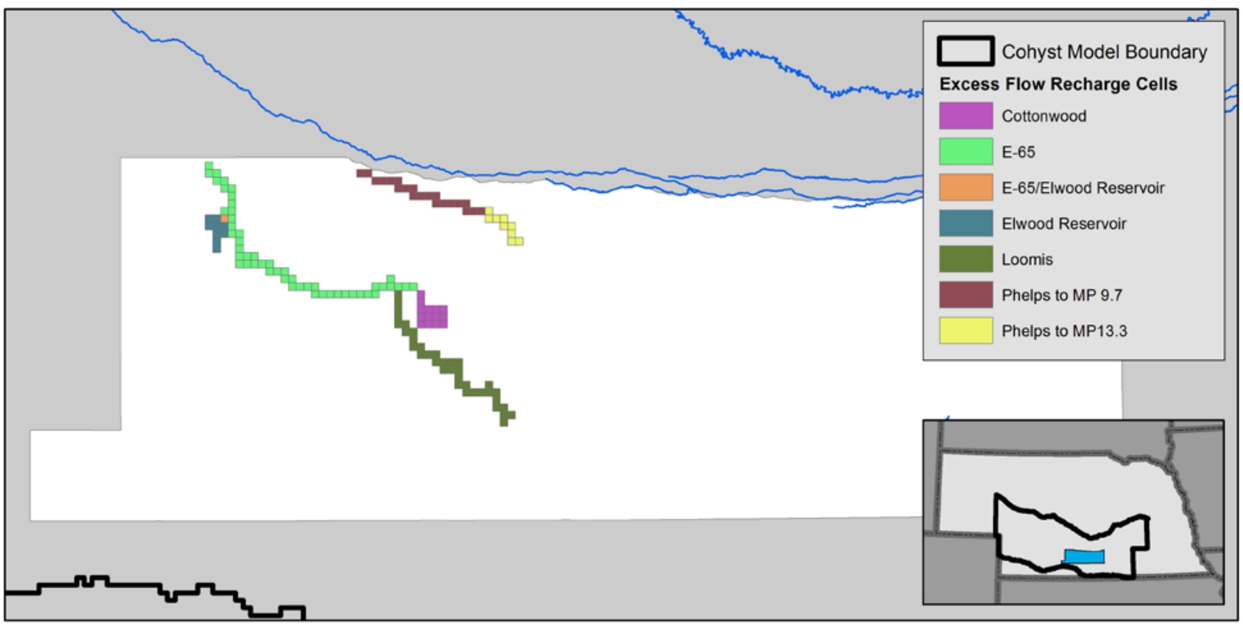

Figure 2. Model cell locations of the TBNRD excess flow recharge events within the COHYST model area.

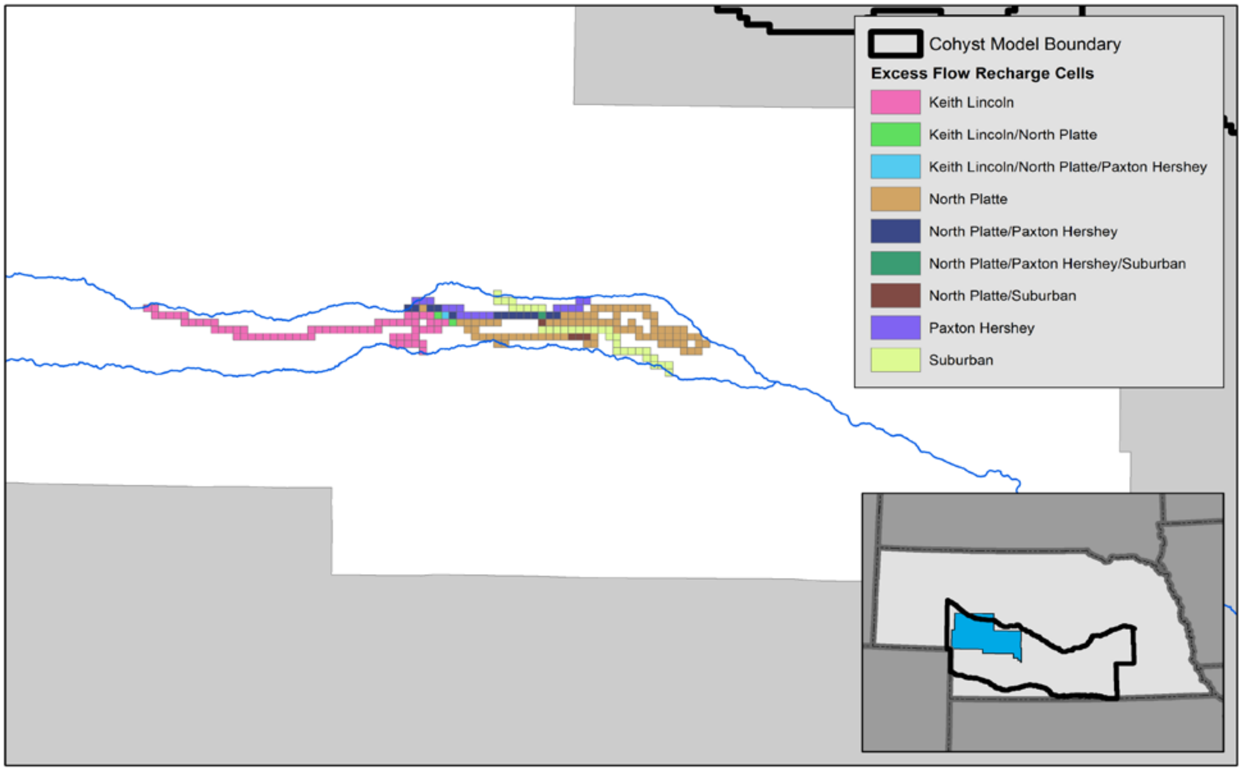

Figure 3. Model cell locations for the TPNRD excess flow recharge events within the COHYST model area.

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
1/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
3/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	0	0	0	0	0	0
4/1/2011	65	0	0	22	0	0	0	0	0	0	0	0	0	14	3.5	0	0	392	0	0	0	0	0	0
4/2/2011	56	0	0	17	0	0	0	0	0	0	0	0	0	12	8.2	0	0	404	0	0	0	0	0	0
4/3/2011	53	3	0	2.9	0	0	0	0	0	0	0	0	0	21	0.91	2.7	0	402	0	0	0	0	0	0
4/4/2011	43	0	0	7.6	0	0	51	0	0	0	0	0	0	48	0.98	64	0	400	7	0	24	0	0	0
4/5/2011	31	17	0	11	0	0	57	0	0	0	0	0	0	46	0	62	0	402	32	0	35	0	0	0
4/6/2011	22	30	2	13	0	0	49	0	480	0	0	0	0	43	0	40	0	433	32	0	29	0	0	0
4/7/2011	26	26	5.5	10	0	0	45	0	457	0	0	21	0	43	0	50	0	415	32	0	23	0	0	0
4/8/2011	39	28	14	8.7	0	0	45	0	414	0	0	35	0	44	0	55	0	404	32	0	25	0	0	0
4/9/2011	67	37	9.1	7.5	0	0	45	0	378	0	0	27	0	46	0	56	0	404	32	0	22	0	0	0
4/10/2011	39	28	4.3	7.7	0	0	45	0	378	0	0	31	0	44	0	58	0	402	32	0	22	0	80	0
4/11/2011	36	29	0	8.1	0	0	45	0	360	12	0	30	0	42	0	59	0	404	31	0	18	0	81	0
4/12/2011	34	29	0	8.1	0	0	44	0	339	95	0	28	0	43	0	55	0	404	30	0	18	0	80	0
4/13/2011	33	29	0	8.5	0	0	44	0	332	69	0	28	47	43	0	56	0	402	31	0	16	0	80	0
4/14/2011	32	29	0	9	0	0	44	0	332	59	0	28	46	43	2.2	52	0	431	17	0	18	0	84	0
4/15/2011	29	31	0	9.5	0	0	44	0	325	58	53	26	36	42	5.2	30	0	713	0	0	18	0	90	0
4/16/2011	26	22	0	9.7	0	0	44	0	323	58	102	28	33	41	13	0	0	0	0	0	11	0	95	0
4/17/2011	24	22	3.5	31	0	0	44	0	333	58	91	28	35	42	19	0	0	0	0	0	11	0	100	0
4/18/2011	24	23	5.8	20	28	30	44	0	338	68	88	28	39	43	20	0	1.6	0	0	0	11	0	101	0
4/19/2011	22	21	5.5	20	49	62	44	0	316	109	84	28	43	41	13	0	6.6	0	0	0	11	0	104	0
4/20/2011	17	15	6.5	22	49	64	44	0	287	102	106	28	43	39	15	8.3	6.3	0	0	0	7.4	0	100	0
4/21/2011	28	16	6.3	23	41	46	44	0	287	90	116	29	42	40	24	11	6.2	0	0	0	11	0	107	0
4/22/2011	43	17	7.8	20	29	35	45	0	291	91	119	30	37	43	20	18	8.2	0	5.9	0	15	46	102	0
4/23/2011	37	22	6.6	26	28	34	44	0	279	89	121	30	27	43	17	28	6.9	0	11	0	13	68	98	0
4/24/2011	32	24	9.6	29	28	34	44	0	278	89	120	30	25	45	16	27	5	0	14	0	11	68	102	0
4/25/2011	32	25	9.8	29	28	23	44	0	277	89	123	30	30	47	17	32	7.8	0	24	0	11	68	92	0
4/26/2011	31	28	9.7	29	28	23	44	0	279	89	121	30	39	49	16	50	9	0	25	0	14	69	76	0
4/27/2011	27	31	11	25	28	27	41	0	274	90	127	8.4	34	49	17	60	6.5	0	28	0	14	70	73	0
4/28/2011	29	26	11	19	28	26	38	0	274	89	86	18	34	46	24	61	5.4	0	28	0	13	71	88	0
4/29/2011	28	27	14	18	28	25	37	0	276	87	47	34	34	44	29	60	2	0	26	0	20	71	87	0
4/30/2011	25	29	17	17	28	24	37	0	268	84	46	0	33	43	30	65	0.99	0	25	0	25	70	66	0
5/1/2011	21	28	17	18	28	23	36	0	275	82	44	21	35	42	29	68	12	0	25	0	23	71	66	0
5/2/2011	26	27	18	17	28	23	35	0	267	84	41	26	38	41	29	68	20	0	25	0	23	71	67	0
5/3/2011	28	36	17	17	27	23	35	0	281	83	41	0	38	42	29	71	21	0	25	0	24	71	77	0
5/4/2011	34	43	2.9	0	27	23	0	0	289	83	41	0	38	44	29	73	21	0	25	0	24	71	74	0
5/5/2011	32	34	2.1	0	27	23	0	0	292	83	44	0	39	43	30	74	21	0	26	0	25	71	77	0
5/6/2011	35	39	2.1	0	27	23	0	0	284	84	43	0	39	0	31	71	21	0	26	0	25	71	81	0
5/7/2011	38	52	2.2	0	27	24	0	0	257	84	40	0	39	0	36	68	21	0	26	0	24	71	85	0
5/8/2011	36	54	6.1	0	27	47	0	0	267	84	38	0	39	0	35	73	21	0	27	0	30	71	89	0
5/9/2011	37	56	13	0	28	60	0	0	274	84	44	0	39	0	44	69	23	0	27	0	30	74	76	0
5/10/2011	34	59	13	0	27	64	0	0	0	85	46	0	39	0	44	64	23	0	27	0	28	75	76	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
5/11/2011	44	0	13	0	27	65	0	0	0	85	43	0	34	0	40	67	18	0	28	0	28	75	42	0
5/12/2011	0	0	14	0	27	71	0	0	0	86	39	0	43	0	39	75	6.5	0	28	0	29	76	29	0
5/13/2011	0	0	13	0	24	77	0	0	0	86	36	0	32	0	41	74	12	0	28	0	28	76	48	0
5/14/2011	0	0	12	0	19	78	0	0	0	84	34	0	41	0	45	73	18	0	28	0	28	75	43	0
5/15/2011	0	0	12	0	17	76	0	0	0	80	39	0	45	0	44	73	17	0	28	0	29	73	48	0
5/16/2011	0	0	13	0	17	71	0	0	0	83	0	0	35	0	43	73	18	0	29	0	29	76	68	0
5/17/2011	0	0	14	0	20	70	0	0	0	83	0	0	35	0	47	76	17	0	0	0	29	75	76	0
5/18/2011	0	0	14	0	22	70	0	0	0	84	0	13	42	0	38	79	17	0	0	0	30	76	53	0
5/19/2011	0	0	14	0	23	66	0	0	0	83	0	32	0	0	39	0	18	0	0	0	0	77	59	0
5/20/2011	0	0	13	0	0	63	0	0	0	0	0	40	0	0	35	0	19	0	0	0	0	77	72	0
5/21/2011	0	0	13	0	0	63	0	0	0	0	0	39	0	0	41	0	19	0	0	0	0	77	76	0
5/22/2011	0	0	13	0	0	75	0	0	0	0	0	25	0	0	41	0	19	0	0	0	0	77	88	0
5/23/2011	0	0	13	0	0	86	0	0	0	0	0	32	0	0	35	0	16	0	0	0	0	79	78	0
5/24/2011	0	0	12	0	0	108	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	80	74	0
5/25/2011	0	0	9.3	0	0	112	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	66	48	0
5/26/2011	0	0	12	0	0	103	0	0	0	0	0	38	0	0	0	0	0	0	0	0	0	53	65	0
5/27/2011	0	0	12	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	0	0	0	70	73	0
5/28/2011	0	0	12	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	71	64	0
5/29/2011	0	0	13	0	0	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	0	67	67	0
5/30/2011	0	0	14	0	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	0	0	66	75	0
5/31/2011	0	0	12	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	75	0
6/1/2011	0	0	12	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	57	0
6/2/2011	0	0	12	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0
6/3/2011	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
7/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	0	0
9/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	0	0
9/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/10/2011	0	0	0	0	0	74	0	0	0	88	0	0	0	0	0	0	0	0	0	0	0	78	0	0
9/11/2011	0	0	0	0	0	73	0	0	0	87	0	0	0	0	0	0	0	0	0	0	0	78	0	0
9/12/2011	0	0	0	0	0	72	0	0	0	87	0	0	0	0	0	0	26	0	0	0	0	78	0	0
9/13/2011	0	0	0	0	0	72	0	0	0	87	0	0	0	0	0	0	26	0	0	0	0	78	0	0
9/14/2011	0	0	0	0	0	70	0	0	0	87	0	0	0	0	0	0	26	0	0	0	0	80	0	0
9/15/2011	0	0	0	0	0	71	0	0	0	87	0	0	0	0	0	0	26	0	0	0	34	81	0	0
9/16/2011	0	0	0	0	29	61	0	0	0	86	0	0	0	0	0	0	26	0	0	0	31	81	0	0
9/17/2011	0	0	0	0	23	61	0	0	0	87	0	0	0	0	0	0	27	0	0	0	30	82	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
9/18/2011	0	0	0	0	20	58	0	0	0	85	0	0	0	0	0	0	26	0	0	0	33	81	0	0
9/19/2011	0	0	0	0	20	56	0	0	0	84	0	0	0	0	0	0	24	0	33	0	30	81	0	0
9/20/2011	0	0	0	0	31	55	0	0	0	83	0	62	19	0	0	0	26	0	33	0	28	81	0	0
9/21/2011	0	0	0	0	37	54	0	0	0	83	0	54	29	0	0	0	28	0	33	0	28	81	92	0
9/22/2011	0	0	0	0	37	53	0	0	0	84	0	36	37	0	0	0	28	0	33	0	28	81	97	0
9/23/2011	0	0	0	0	37	52	0	0	0	87	0	29	49	0	0	17	28	0	33	0	28	81	103	0
9/24/2011	0	0	0	0	37	52	0	0	0	87	0	27	36	0	0	23	28	0	33	0	28	81	110	0
9/25/2011	0	0	0	0	37	52	0	0	0	87	0	27	27	0	0	30	28	0	33	0	28	81	106	0
9/26/2011	0	0	0	0	37	51	0	0	0	88	0	26	22	0	0	68	28	0	33	0	28	81	103	0
9/27/2011	37	0	0	0	29	50	0	0	0	88	0	26	34	0	0	67	28	0	33	0	28	81	110	0
9/28/2011	37	0	0	0	22	49	0	0	0	88	0	26	31	0	0	66	28	0	33	107.0245833	28	81	101	0
9/29/2011	36	0	0	0	23	48	0	0	0	88	0	26	33	0	0	63	27	0	33	130.7943552	28	80	80	0
9/30/2011	37	0	0	0	23	44	0	0	0	88	0	26	34	0	0	67	25	0	33	66.27578399	28	80	82	0
10/1/2011	34	0	14	0	23	44	0	0	0	89	0	26	40	49	0	69	23	0	33	55.71881339	28	79	87	0
10/2/2011	27	0	21	0	23	44	0	0	0	89	0	26	27	46	0	68	24	0	33	22.75661044	27	79	84	0
10/3/2011	30	0	19	0	25	44	0	0	0	89	0	15	32	48	0	67	26	0	33	21.96796914	27	33	86	0
10/4/2011	26	0	22	0	27	44	0	0	0	89	0	17	27	51	0	66	26	0	32	33.35316094	23	0	94	0
10/5/2011	27	39	19	0	27	42	0	0	0	86	0	26	14	52	0	65	25	0	34	31.1066026	18	0	91	0
10/6/2011	26	34	18	0	25	41	0	0	0	83	0	25	6.2	51	0	64	22	0	34	26.21892733	25	0	78	0
10/7/2011	29	29	17	0	23	40	0	0	0	82	0	25	25	52	0	65	19	0	33	27.76251847	25	0	82	8.7
10/8/2011	27	31	22	0	25	40	0	0	0	85	0	27	25	62	0	68	20	0	30	18.70105505	13	0	77	10
10/9/2011	32	29	17	0	25	40	0	0	0	83	0	27	30	60	0	66	22	0	33	16.50571029	17	0	78	11
10/10/2011	29	25	20	0	16	39	0	0	0	82	0	27	21	56	22	65	19	0	33	25.62372614	31	0	84	9.7
10/11/2011	26	22	20	0	0	39	0	0	0	82	0	27	9.9	54	18	68	17	0	32	29.49386531	28	0	86	8.1
10/12/2011	23	21	20	0	0	39	0	0	0	81	0	27	21	55	14	70	12	0	33	26.40047254	28	0	86	7.5
10/13/2011	27	19	20	0	0	17	0	0	0	52	0	27	27	54	10	80	0	0	35	25.9602625	28	0	89	7.7
10/14/2011	31	18	16	34	0	0	0	0	0	0	0	26	26	51	6.7	82	0	0	36	27.32035996	28	0	90	7.9
10/15/2011	29	16	16	32	0	0	0	0	0	0	0	26	25	49	16	82	0	0	36	30.30356712	28	0	90	7.6
10/16/2011	28	15	13	31	0	0	0	0	0	0	0	26	23	45	16	83	0	0	35	31.55053162	28	0	90	7.9
10/17/2011	27	14	10	30	0	0	0	0	0	0	0	25	20	41	16	82	0	0	35	32.14070129	21	0	90	7.7
10/18/2011	25	13	9.6	30	0	0	0	0	0	0	0	27	16	39	13	73	0	0	33	32.45730879	0	0	90	7.5
10/19/2011	22	12	8.6	29	0	0	0	0	0	0	0	27	16	35	12	71	0	0	31	31.60906005	0	0	90	7.5
10/20/2011	20	12	7.3	28	0	0	0	0	0	0	0	26	22	32	11	71	0	0	30	30.55971707	0	0	90	7.7
10/21/2011	19	11	6.3	27	0	0	0	0	0	0	0	27	21	27	10	71	0	0	29	30.10753279	0	0	90	7.5
10/22/2011	18	11	8.1	26	0	0	0	0	0	0	0	27	19	26	8.4	70	0	0	29	30.71397968	0	0	90	7.5
10/23/2011	19	10	9.3	25	0	0	0	0	0	0	0	26	4.9	23	5.6	70	0	0	15	31.29432116	0	0	90	7.1
10/24/2011	18	9.6	8.6	25	0	0	0	0	0	0	0	27	0	20	0.67	70	0	0	6.3	31.39295055	0	0	90	7.1
10/25/2011	17	9.2	7.9	25	0	0	0	0	0	0	0	27	0	18	0	71	0	0	6	31.81079293	0	0	90	6.6
10/26/2011	16	8.8	6.9	25	0	0	0	0	0	0	0	12	0	17	0	29	0	0	6.2	31.32254123	0	0	90	6.4
10/27/2011	16	8.6	6.9	25	0	0	0	0	0	0	0	12	0	17	0	0	0	0	6.2	31.03914659	0	0	90	9
10/28/2011	15	7.8	6.1	24	0	0	0	0	0	0	0	0	0	15	0	0	0	0	6.4	30.99669949	0	0	90	9
10/29/2011	14	7.4	4.2	23	0	0	0	0	0	0	0	0	0	14	0	0	0	0	6.4	31.01082991	0	0	90	9
10/30/2011	13	6.9	0	20	0	0	0	0	0	0	0	0	0	13	0	0	0	0	5.8	31.84057248	0	0	90	9
10/31/2011	13	6.6	0	20	0	0	0	0	0	0	0	0	0	12	0	0	0	0	3	32.69996217	0	0	90	9
11/1/2011	5	6.2	0	20	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	31.26940491	0	0	90	9
11/2/2011	0	6.3	0	24	0	0	0	0	0	0	0	0	0	3.9	0	0	0	0	0	29.26379644	0	0	90	9
11/3/2011	0	6.8	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.61045523	0	0	90	9
11/4/2011	0	7.4	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31.30914677	0	0	90	9
11/5/2011	0	8.1	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30.92692318	0	0	72	9
11/6/2011	0	8.8	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.66091242	0	0	68	10
11/7/2011	0	9.5	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.4802135	0	0	65	10
11/8/2011	0	10	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.21421057	0	0	63	0
11/9/2011	0	10	0	4.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.04828308	0	0	62	0
11/10/2011	0	9.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.77270441	0	0	58	0
11/11/2011	0	7.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.82751547	0	0	55	0
11/12/2011	0	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.74536424	0	0	40	0
11/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.78684948	0	0	35	0
11/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.69062646	0	0	12	0
11/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.75901254	0	0	0	0
11/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.81379455	0	0	0	0
11/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.3674676	0	0	0	0
11/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.06163742	0	0	0	0
11/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.21435512	0	0	0	0
11/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.14384701	0	0	0	0
11/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.25569608	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
11/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.26976879	0	0	0	0
11/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.17199244	0	0	0	0
11/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.19977155	0	0	0	0
11/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26.38807493	0	0	0	0
11/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25.49514785	0	0	0	0
11/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26.31471992	0	0	0	0
11/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.1202245	0	0	0	0
11/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32.22353539	0	0	0	0
11/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30.19276729	0	0	0	0
12/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.25784596	0	0	0	0
12/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.00605042	0	0	0	0
12/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26.26838394	0	0	0	0
12/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23.59863297	0	0	0	0
12/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.65851702	0	0	0	0
12/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.1829093	0	0	0	0
12/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.44082576	0	0	0	0
12/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25.36887359	0	0	0	0
12/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23.73413124	0	0	0	0
12/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.15072983	0	0	0	0
12/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.41524308	0	0	0	0
12/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.86557985	0	0	0	0
12/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.59032798	0	0	0	0
12/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.2423059	0	0	0	0
12/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.82674941	0	0	0	0
12/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.16926831	0	0	0	0
12/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.98407558	0	0	0	0
12/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.81960907	0	0	0	0
12/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.36881778	0	0	0	0
12/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15.62049278	0	0	0	0
12/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.91246182	0	0	0	0
12/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.76136171	0	0	0	0
12/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.8645644	0	0	0	0
12/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.72761418	0	0	0	0
12/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.46246447	0	0	0	0
12/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.26676907	0	0	0	0
12/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.17556774	0	0	0	0
12/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.20950242	0	0	0	0
12/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.27926976	0	0	0	0
12/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.98344119	0	0	0	0
12/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.57826339	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
1/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.46557587	0	0	0	0
1/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.49902963	0	0	0	0
1/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.33391967	0	0	0	0
1/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.11774274	0	0	0	0
1/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.556257488	0	0	0	0
1/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
3/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.2	0	0	0	0	0	0
3/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
3/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.9	0	0	0	0	0	0
3/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.7	0	0	0	0	0	0
3/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.5	0	0	0	0	0	0
3/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
5/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
7/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
9/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
11/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
1/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
3/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
5/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

POAC_2011_2013.xlsx

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
7/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
9/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0	0	43	0	0	0	0	0
9/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0	0	42	0	0	0	0	0
9/18/2013	0	0	0	0	0	0	0	0	0	3.8	0	0	0	0	0	64	0	0	40	0	0	0	137	0
9/19/2013	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	67	0	0	43	0	0	0	192	0
9/20/2013	0	0	0	0	0	0	0	51	0	3.7	0	0	0	0	0	81	0	0	43	485	0	0	202	0
9/21/2013	0	0	0	0	0	0	0	68	0	3.3	0	0	0	0	0	88	0	0	34	109	0	0	184	0
9/22/2013	0	0	0	0	0	0	0	92	0	17	0	0	0	0	0	86	0	0	31	36	0	203.305675	143	0
9/23/2013	0	0	0	0	0	70	0	84	0	106	0	0	0	0	0	87	0	0	34	36	0	247.93375	99	0
9/24/2013	0	0	0	0	0	72	0	54	0	104	0	0	0	0	0	89	0	0	39	36	0	225.6197125	62	0
9/25/2013	0	0	0	0	0	69	0	52	0	98	0	0	0	0	0	88	0	0	35	36	0	230.5783875	61	0
9/26/2013	0	0	0	0	0	59	0	52	0	91	0	0	0	0	0	85	0	0	30	36	0	203.305675	45	0
9/27/2013	0	0	0	0	0	56	0	85	0	87	0	0	0	0	0	76	0	0	38	36	0	195.8676625	49	0
9/28/2013	0	0	0	0	0	52	0	33	0	85	0	0	0	0	0	68	0	0	44	36	0	190.9089875	43	0
9/29/2013	0	0	0	0	0	48	0	53	0	72	0	0	0	0	0	67	0	0	34	36	0	180.9916375	18	0
9/30/2013	0	0	0	0	0	44	0	52	0	72	0	0	0	0	0	66	0	0	33	36	0	183.470975	43	0
10/1/2013	0	0	0	0	0	40	0	51	0	79	0	0	0	0	0	70	0	0	38	36	0	205.7850125	49	0
10/2/2013	0	0	0	0	0	44	0	56	0	73	0	0	0	0	0	71	0	0	40	36	0	198.347	48	0
10/3/2013	0	0	0	0	0	63	0	58	0	79	0	0	0	0	0	76	0	0	37	36	0	190.9089875	56	0
10/4/2013	0	0	0	0	0	0	0	57	0	62	0	0	0	0	0	74	0	0	34	36	0	195.8676625	45	0
10/5/2013	0	0	0	0	0	55	0	55	0	43	0	0	0	0	0	72	0	0	31	36	0	183.470975	50	0
10/6/2013	0	0	0	0	0	41	0	50	0	24	0	0	0	0	0	71	0	0	28	36	0	190.9089875	48	0
10/7/2013	0	0	0	0	0	34	0	45	0	11	0	0	0	0	0	64	0	0	28	36	0	171.0742875	43	0
10/8/2013	0	0	0	0	0	10	0	37	0	6	0	0	0	0	0	53	0	0	28	36	0	158.6776	41	0
10/9/2013	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0	44	0	0	27	36	0	133.884225	47	0
10/10/2013	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0	27	0	0	29	36	0	74.380125	62	0
10/11/2013	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	3.8	0	0	14	36	0	32.2313875	49	0
10/12/2013	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	3.6	0	0	0	36	0	0	44	0
10/13/2013	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	36	0	0	35	0
10/14/2013	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	36	0	0	39	0
10/15/2013	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	2.2	36	0	0	58	0
10/16/2013	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	36	0	0	55	0
10/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	50	0
10/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	45	0
10/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	49	0
10/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	53	0
10/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	22	0
10/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0
10/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	39	0
10/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	61	0
10/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	0	40	0
10/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	19	0
10/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	1.6	0
10/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0
10/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
11/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A.1.8 Memorandum October 2018 Update: Post 97 Analysis WWUMM

Memorandum

To:	Kari Burgert, DNR
From:	The Flatwater Group, Inc.
Subject:	October 2018 Update: Post 97 Analysis – Western Water Use Model (WWUM) Area
Update:	10/11/2018

A. Introduction

The Flatwater Group, Inc. (TFG) was tasked by the Nebraska Department of Natural Resources (DNR) with developing recharge and pumping files (.RCH and .WEL files, respectively) for several Post 97 Analysis scenarios in the WWUM area. Section B of this memorandum describes the setup of the model TFG used to develop these files. TFG's task originally consisted of developing 7 simulation runs which were divided into two groups based upon assumed future (scenario years 2014-2063) climate conditions:

Group 1: 50-year projection by repeating a 25-year historical period (1989-2013) twice; and
Group 2: 50-year projection by repeating a five-year historical period (2009-2013) ten times.

Section C describes the inputs for the Group 1 model runs and is organized as follows:

- C1. Baseline Scenario
- C2. No Groundwater Only Pumping Scenario
- C3. Post 97 Development Rollback Scenario

Section D describes the inputs for the Group 2 model runs and is organized as follows:

- D1. Metered Baseline Scenario
- D2. Metered Baseline Scenario: No Groundwater Only Pumping Scenario
- D3. Metered Baseline Scenario: Simulated Groundwater Pumping Scenario
- D4. Metered Baseline Scenario: Post 97 Development Rollback Scenario

TFG's task was updated in October 2018 to develop files (.RCH and .WEL files) for seven additional runs based on the Group 2 (Section D) model setup. For these runs, revised canal recharge and municipal and industrial (M&I) pumping information was used; and is described in section E.

Section F describes the inputs for each of the seven additional runs and is organized as follows:

- F1_a. Metered Baseline Scenario with updated canal recharge and M&I pumping
- F1_b. Metered Baseline Scenario without canal recharge or M&I pumping
- F2_a. Metered Baseline Scenario: No Groundwater Pumping with updated canal recharge and no M&I Pumping
- F2_b. Metered Baseline Scenario: No Groundwater Pumping without canal recharge or M&I pumping
- F3_a. Metered Baseline Scenario: Post 97 Rollback Scenario with updated canal recharge and 1997 level of M&I pumping
- F3_b. Metered Baseline Scenario: Post 97 Rollback Scenario with updated canal recharge and historic levels of M&I pumping

F3_c. Metered Baseline Scenario: Post 97 Rollback Scenario without canal recharge or M&I pumping

B. Model Setup[1]

The watershed model utilized for DNR's Post 97 analysis was based upon the historically calibrated Western Water Use Model (WWUM). Inputs were incorporated from the results of the Historically Calibrated Model (Run028) and the Conservation Study's Baseline (Base001). Several modifications were necessary to implement the scenarios through the watershed model. All scenario changes were made to region 1 of the WWUM. Regions 2-6 remained consistent with the Historically Calibrated Model and did not vary from scenario to scenario.

B1. Climate

The climate inputs for the watershed model remained consistent with the Historically Calibrated Model's inputs.

B2. Land Use

The Post 97 analysis converted from a parcel and cell-based approach, to strictly a cell-based approach. This methodology was chosen to simplify the manipulation of the data sets used for the scenarios. This required three different land use data sets.

1) Baseline Data Set (LU004)
   The baseline data set was acquired directly from the Historically Calibrated Model. No modifications were made.

2) No Groundwater Only Pumping Data Set (LU004_ngwp)
   The No Groundwater Only Pumping data set was developed by making alterations to the Baseline Data Set. All groundwater only irrigated lands were converted to dryland cropping maintaining the crop mix.

3) Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (LU004_p97)
   The Post 97 data set was developed by making alterations to the Baseline Data Set. For the years 1953 through 1997 the land use remained constant. Between 1998 and 2013 surface water only and comingled lands were developed as seen in the Baseline Data Set, while groundwater only irrigated lands were kept at 1997 levels. The balance of the acres within a cell were handled one of three ways:

   - If the number of irrigated acres[2] in the cell exceeded 40.0 acres, the excess acres remained in the model and the dryland acres were set to 0.0. The annual total of excess acres never exceeded 1,000 acres and was typically less than 125 per year.
   - If the irrigated acres were less than 40.0 acres, but the irrigated acres plus the dry acres were greater than 40.0 acres; acres were removed from the dryland crops until the total number of acres was equal to 40.0[3].

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[1] All alterations to the land use occurred strictly in WWUM region 1.

[2] Irrigated acres are defined as the total of the land use file year's surface water only and comingled irrigated acres plus the 1997 groundwater only irrigated acres.

[3] The removal process proceeded in order from crop 1 to crop 12.

- If the irrigated acres plus the dryland acres was less than 40.0 acres, the balance was added as dryland corn.

B3. Irrigation Estimates

Typically, in the WWUM, the irrigation volumes applied within a cell are first determined on a parcel basis then divided among the cells which the parcel overlays. At the same time, an application efficiency for the cell is determined weighted, according to the volume applied by either sprinklers or flood irrigation. The migration from the parcel-based approach to the cell-based approach yields the need to develop a new way to initialize the volume of applied water. This method will be described for each scenario and replaces the 'Parcel_Pump_wSWdel' program in the RSWB.

The irrigation estimates were copied from either the Conservation Study baseline or the Calibrated Historical model. The conservation study represents a scenario where all irrigation volumes are simulated to meet a target NIR. Furthermore, methodology between determining the irrigation split on comingled lands consistently uses the 'mutual ditch' across all canals.

The irrigation volumes in the Calibrated Historical model include diversion records and metered pumping supplemented by simulated volumes based on a target NIR. Additionally, the surface water canals in the area use different methodology to determine the irrigation split on comingled lands; incorporating either a 'mutual ditch' or a 'maximum supply' approach.

Simulated irrigation volumes use one of two sets of NIR values. Set 1 is based on 95% of the CROPSIM predicted NIR. Set 2 is based on 95% of the CROPSIM predicted NIR for all crops except Alfalfa, Small Spring Grains, and Irrigated Pasture which are set at 80% of the CROPSIM predicted NIR.

B4. Virtual Pumping in the '.WEL' file

Another by-product of migrating from the parcel based approach was the removal of the link between the cell on which the pumping was applied and the certificate and well from which it was pumped. Rather, for all runs in this analysis a 'virtual pumping' technique was used in which pumping was extracted from the cell it was applied.

B5. Call Year Routine

A call year routine was initiated in each program of the RSWB to allow for the projection of the model results into a period of time where no input files exist. The call year file was able to control the land use, climate, application efficiency, canal recharge, miscellaneous pumping and recharge, and municipal and industrial pumping which was included in the simulation years results.

B6. Canal Recharge, Miscellaneous Pumping and Recharge, Municipal and Industrial pumping

Canal recharge was obtained from the conservation study's baseline inputs. Two canal recharge data sets were used; the baseline NPNRD data set and the Western Canal and Pumpkin Creek data set. For the model projected simulation years, the canal recharge annual file from the simulated climate year was used. For example, in 2063 climate from 2013 was used; therefore, canal recharge values from 2013 were also used.

Miscellaneous pumping and recharge was obtained from the datasets used to create the Calibrated Historical Model. These datasets included UNW_Run012, WCOHYST_Run025, Western_002, Colorado002, and Wyoming002 for regions 2-6. The miscellaneous pumping and recharge files matched the representative year for the simulated climate. For example, in 2063 the climate is represented by

2013; however, there is no 2013 data for the Region 4, rather it is copied from 2010. Therefore, 2010 data for region 4 will be included in the results for 2063.[4]

There is no municipal and industrial pumping included in any scenarios.

[4] The projected years used the same canal recharge and miscellaneous inputs as the as the climate year used to represent projected year. This information is defined in the WWUM watershed model documentation.

C. Post 97 Scenarios with 25 Year Period Projected Twice

The following description defines the changes made to the model. Each scenario is implemented in Region 1 then combined with the pumping and recharge from UNW_Run012, WCOHYST_Run025, Colorado002, Western002, and Wyoming002; and the canal recharge from Base001 and WPC001 to create the '.WEL' and '.RCH' file for inclusion in the groundwater model.

C1. Baseline Scenario (1953-2063) (Baseline001)

Deliverable: WWUM_p97_Baseline001.zip
Date: 10/24/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the conservation study's baseline scenario
Comingled Pumping:	Copied from the conservation study's baseline scenario
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the conservation study's baseline scenario
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	1989-2013 repeated twice
Land use:	Baseline Data Set: year 2013
Surface Water Deliveries:	Simulated to meet a target NIR
NIR Set:	1
Comingled Pumping:	Simulated to meet a target NIR
NIR Set:	1
Comingled Split:	85%[5] surface water 15% groundwater
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the conservation study's baseline scenario's year 2013
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

[5] The conservation study's baseline had an average split of 85%-15% on comingled irrigation 1989-2013.

C2. No Groundwater Only Pumping Scenario (1953-2063) (NGWP_001)

Deliverable: WWUM_p97_NGWP_001_20171026.zip
Date: 10/26/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	No Groundwater Only Pumping Data Set
Surface Water Deliveries:	Copied from the conservation study's baseline scenario
Comingled Pumping:	Copied from the conservation study's baseline scenario
Groundwater Pumping:	None
Application Efficiency:	Copied from the conservation study's baseline scenario
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	1989-2013 repeated twice
Land use:	No Groundwater Only Pumping Data Set: year 2013
Surface Water Deliveries:	Simulated to meet a target NIR
NIR Set:	1
Comingled Pumping:	Simulated to meet a target NIR
NIR Set:	1
Comingled Split:	85% surface water 15% groundwater
Groundwater Pumping:	None
Application Efficiency:	Copied from the conservation study's baseline scenario's year 2013
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

C3. Post 97 Development Rollback Scenario (p97_001)

Deliverable: WWUM_p97_p97_001_20171025.zip
Date: 10/25/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the conservation study's baseline scenario
Comingled Pumping:	Copied from the conservation study's baseline scenario
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the conservation study's baseline scenario
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	1989-2013 repeated twice
Land use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set: year 2013
Surface Water Deliveries:	Simulated to meet a target NIR
NIR Set:	1
Comingled Pumping:	Simulated to meet a target NIR
NIR Set:	1
Comingled Split:	85% surface water 15% groundwater
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the conservation study's baseline scenario's year 2013
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

D. Post 97 Scenarios with 5 Year Period Projected 10 times

The following description defines the changes made to the model. Each scenario is implemented in Region 1 then combined with the pumping and recharge from UNW_Run012, WCOHYST_Run025, Colorado002, Western002, and Wyoming002; and the canal recharge from Base001 and WPC001 to create the '.WEL' and '.RCH' file for inclusion in the groundwater model.

D1. Metered Baseline Scenario (1953-2063) (HistBase_001)

Deliverable: WWUM_p97_HistBase_001_20171030.zip
Date: 10/30/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

D2. Metered Baseline Scenario: No Groundwater Pumping (1953-2063) (Histngwp_001)
Deliverable: WWUM_p97_Histngwp_001_20171030.zip
Date: 10/30/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

D3. Metered Baseline Scenario: Simulated Groundwater Pumping (1953-2063) (HistNIR_002)

Deliverable: WWUM_p97_HistNIR_002_20171208.zip
Date: 12/8/2017

Simulation Period (1953-2006)

Climate:	1953-2006
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model[6]
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2007-2013)

Climate:	2007-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

[6] During this period groundwater pumping in the Historically Calibrated Model is simulated

D4. Metered Baseline Scenario: Post 97 Development Rollback Scenario (1953-2063) (Hist_p97_001)

Deliverable: WWUM_p97_Hist_p97_001_20180302.zip
Date: 3/2/2018

Simulation Period (1953-1997)

Climate:	1953-1997
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (Same as the baseline for this period of time)
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model (During this period groundwater pumping in the Historically Calibrated Model is simulated)
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (1998-2013)

Climate:	1998-2013
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

E. Update to the Post 97 Analysis Scenario Input files *Updated October 2018

The Metered Baseline Scenarios were updated to include new canal recharge and municipal and industrial (M&I) pumping data. The new groundwater model inputs were created by appending the new data sets to existing agricultural pumping and recharge datasets.

E1. Updates to the Model Setup: Canal Recharge, M&I Pumping
This section replaces section B6 of the model setup for future runs.

Adaptive Resources, Inc. (ARI) develop an update version of the canal recharge inputs: *WWUM_ConveyanceLoss_28092018.csv*. Data was provided for the period 1953-2013. This information was provided to DNR. DNR then provided the information to TFG on October 1, 2018. This canal recharge data was compiled and formatted into the canal recharge data set *WWUMrr_001* which replaced the data sets *Base001* and *WPC001*. For the model projected simulation years, the canal recharge annual file from the simulated climate year was used. For example, in 2063 climate from 2013 was used; therefore, canal recharge values from 2013 were also used.

ARI also developed a set of Municipal and Industrial pumping data: *rr2018_muni_ind_inpu.csv*. Data was provided for the period May 1953 through 2063[7]; with instruction that the 2014-2063 was repeated from the years 2009-2013. The data was provided in ft^3/day. ARI provided this information to DNR. DNR then provided the information to TFG on October 1, 2018. The M&I data was converted in AF/mon[8] using the actual number of calendar days for each month. Then compiled and formatted into the M&I data set *MIrr_001*.

The following description defines the changes made to the model. Each scenario is implemented in Region 1 then combined with the pumping and recharge from UNW_Run012, WCOHYST_Run025,

[7] It should be noted that prior to 1997 there was no M&I pumping in the provided data
[8] Or AF/stress period

Colorado002, Western002, and Wyoming002 to create the '.WEL' and '.RCH' file for inclusion in the groundwater model.

F. Post 97 Scenarios with 5 Year Period Projected 10 times *Updated October 2018

Section 0 describes the runs which incorporates the changes to the DNR Post 97 Analysis defined in Section E.

F1. Metered Baseline Scenario (1953-2063) (HistBase_001) Updated

These runs use the same agricultural pumping and recharge as *Metered Baseline Scenario (HistBase_001)* from section D1.

F1_a. Metered Baseline Scenario (1953-2063) (HistBase_001) with updated canal recharge and M&I pumping

Deliverable: WWUM_p97_HistBase_001_CnlSeep_MI_20181010.zip
Date: 10/10/2018

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	Yes – as specified by ARI dataset
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F1_b. Metered Baseline Scenario (1953-2063) (HistBase_001) without canal recharge or M&I pumping

Deliverable: WWUM_p97_HistBase_001_NoCnlSeep_NoMI_20181010.zip
Date: 10/10/2018

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F2. Metered Baseline Scenario: No Groundwater Pumping (1953-2063) (Histngwp_001) *Updated

These runs use the same agricultural pumping and recharge as *Metered Baseline: No Groundwater Pumping (Histngwp_001)* from section D2.

F2_a. Metered Baseline Scenario: No Groundwater Pumping (1953-2063) (Histngwp_001) with updated canal recharge and without M&I pumping

Deliverable: WWUM_p97_HistNgwp_001_CnlSeep_NoMI_20181010.zip
Date: 10/10/2018

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F2_b. Metered Baseline Scenario: No Groundwater Pumping (1953-2063) (Histngwp_001) without canal recharge or M&I pumping

Deliverable: WWUM_p97_HistNgwp_001_NoCnlSeep_NoMI_20181010.zip
Date: 10/10/2018

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F3. Metered Baseline: Post 97 Development Rollback Scenario (Hist_p97_001) *Updated

These runs use the same agricultural pumping and recharge as *Metered Baseline: Post 97 Development Rollback Scenario (Hist_p97_001)* from section D4.

F3_a. Metered Baseline Scenario: Post 97 Development Rollback Scenario (1953-2063) (Hist_p97_001) with updated canal recharge and 1997 level of M&I pumping

Deliverable: WWUM_p97_Hist_p97_001_CnlSeep_97MI_20181011.zip
Date: 10/11/2018

Simulation Period (1953-1997)

Climate:	1953-1997
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (Same as the baseline for this period of time)
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model (During this period groundwater pumping in the Historically Calibrated Model is simulated)
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (1998-2013)

Climate:	1998-2013
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes – At 1997 levels
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	Yes – At 1997 levels
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F3_b. Metered Baseline Scenario: Post 97 Development Rollback Scenario (1953-2063) (Hist_p97_001) with updated canal recharge and Historic levels of M&I pumping

Deliverable: WWUM_p97_Hist_p97_001_CnlSeep_HistMI_20181011.zip
Date: 10/11/2018

Simulation Period (1953-1997)

Climate:	1953-1997
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (Same as the baseline for this period of time)
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model (During this period groundwater pumping in the Historically Calibrated Model is simulated)
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (1998-2013)

Climate:	1998-2013
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	Yes – as specified by ARI dataset
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F3_c. Metered Baseline Scenario: Post 97 Development Rollback Scenario (1953-2063) (Hist_p97_001) without canal recharge or M&I pumping

Deliverable: WWUM_p97_Hist_p97_001_NoCnlSeep_NoMI_20181011.zip
Date: 10/11/2018

Simulation Period (1953-1997)

Climate:	1953-1997
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (Same as the baseline for this period of time)
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model (During this period groundwater pumping in the Historically Calibrated Model is simulated)
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (1998-2013)

Climate:	1998-2013
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

A.1.9 Memorandums on Industrial and Municipal Pumping for WWUMM

Memo

Adaptive Resources, Inc.

To:	John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition
From:	Thad Kuntz, P.G. and Joe Reedy, G.I.
CC:	
Date:	7/18/2018
Re:	Industrial Pumping Analysis, Robust Review Task: Post 1997 Development – Municipal/Industrial Pumping

EXECUTIVE SUMMARY

Adaptive Resources, Inc. (ARI) analyzed available industrial pumping information for both North Platte Natural Resources District and South Platte Natural Resources District as part of the Robust Review Project Analysis for the Western Water Use Management Modeling. The analysis utilized available water meter records for industrial wells in both Districts from 1997 through 2016, augmented with additional historical pumping records drawn from the Department of Natural Resources' (DNR) 2008 industrial survey, to produce a final industrial pumping dataset for the period from 1997 to 2013. The final pumping estimates include actual meter and survey data when available, and use averages estimated from the available data when meter records did not exist for a given well. These data were further limited to the period of active pumping, between well completion and abandonment, when applicable.

ARI also generated an industrial pumping dataset using the pumping capacity information available in the DNR well registration database. This dataset adapted a per capacity pumping estimation method and per capacity pumping categories developed in previous analyses. The dataset used all industrial registered wells in each District, limited to the period of expected active pumping.

Comparison of final pumping estimates revealed significant differences between methods. Pumping estimated with metered data was more variable later in the modeling period, with decreased variability in early pumping. Pumping estimated with capacity data exhibited limited variability, with the potential for significant overestimation of pumping during the modeling period due. There were also significant discrepancies between the wells included in each dataset. This may be due to discrepancies in actual and registered use, the temporary nature of some industrial uses, or meter and reporting requirements that may not capture all wells.

It is the opinion of ARI that industrial pumping estimated from meter records better reflects actual pumping and should be utilized for future analyses of this type. Meter records capture long and short-term variability in the existing pumping record and are likely to benefit from improved accuracy as additional meter data is incorporated. Changes in well metering or well registration reporting may impact the conclusions and data provided in this memo.

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INTRODUCTION

ARI is completing modifications to the baseline model run of the Western Water Use Management Modeling (WWUMM) under Task 1 of the Robust Review Project Analysis (RRPA). This task includes incorporating observed industrial pumping information into the WWUMM. The updated WWUMM will be utilized in Task 6 to compare the observed pumping information with the historical 1997 pumping information for industrial and commercial wells throughout North Platte Natural Resources District (NPNRD) and South Platte Natural Resources District (SPNRD). The analysis of available industrial pumping data utilized two distinct datasets; metered pumping records provided by the Districts, and the Department of Natural Resources (DNR) well registration database. Industrial well data provided by each NRD was parsed using the following assumptions:

- For NPNRD, only wells labeled “commercial” in the NPNRD dataset were used; including wells for Western Sugar and Bridgeport Ethanol Plant, provided separately (41 wells).
    - Wells from 2008 DNR industrial survey also included (1 well).
- For SPNRD, only wells with meters classified as “industrial” were used; including industrial meters on transferred or dual-use wells (40 wells).

Addendum A provides additional notes and information on the evolution of the analysis as additional datasets were considered.

METERED DATA

METHOD

Historical pumping data became available for industrial wells between 2006 and 2014. NPNRD data was provided annually on a certification basis. SPNRD data was provided as totalizing flow meter (TFM) records, including the date the flow meter was read; generally monthly.

NPNRD pumping data was provided as annual volumes. The average annual pumping was calculated using available pumping records from 2008 through 2016. If a record did not exist for a given year, that year was excluded from the average. The calculated annual average was used to fill any year that did not have a pumping record from 1997 through 2013. These annual values represent the actual or estimated pumping per certification in the District.

The certification and well data provided by NPNRD was used to determine all wells joined to a certification. These wells were assigned an active date based upon completion data from the NRD and the Nebraska Department of Natural Resources (NDNR) well permit database. Each well was also assigned an inactive date based upon the abandonment date from the same sources. A monthly array of active-inactive flags was created from the active-inactive dates. This array was used to determine the number of active wells per certification. The final monthly pumping values ($P_{1\ldots12}$) were distributed to each well to create the final pumping schedule for NPNRD industrial pumping. Inactive wells were assigned a pumping value of 0.

The process for calculating and distributing pumping can be described with the following calculations:

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1) Average annual pumping calculated by certification:

$$(Q_1 + Q_2 + \ldots Q_n) \div n = Q_{avg}$$

2) Years with no record filled using the annual average, Q_{avg}
3) Annual pumping distributed to monthly pumping, based on active wells:

$$Q_1 \div 12 = P_{1\ldots12} \text{ for given year}$$

$$P_1 \div \text{active wells count for month} = \text{final monthly pumping}$$

SPNRD pumping data was provided as monthly TFM readings. The readings were taken at irregular intervals for some wells. Additionally, each flow meter provided readings in one of three units: acre-inches, acre-feet, or gallons. The number of decimal and non-decimal significant figures recorded also varied by flow meter; the maximum value the flow meter could record is termed the "roll over" for this text. Data provided by SPNRD was used to convert all readings to cubic feet. Flow meters were generally read at the beginning or end of each month, with the day being largely consistent with the readings on a given meter, but not between meters. Serial dates were used to apportion monthly pumping volumes between adjacent months based upon the current and adjacent serial dates (forward and backward in time). This apportionment was only applied to the first and last month of each year. As TFM records were inconsistent for some wells, the calculated monthly pumping volumes were aggregated annually. Using annual data also allowed for consistency in the pumping distribution between NRDs. If a gap existed across years in TFM records, the estimated volume of pumping during the gap was distributed proportionally between each year based on the number of days per year captured by the gap. This process was applied even if the gap covered multiple years. It is possible estimates calculated in this way may be artificially low, as the flow meter may have "rolled over" during an extended gap. The method for estimating annual pumping from TFM records is demonstrated below:

1) Conversion of TFM record to pumping volume:

$$TFM_n - TFM_{n-1} = Q_n$$

2) Conversion of monthly volumes:

$$Q \text{ in gal, acre-in, acre-f} \div \text{conversion factor} = Q\ ft^3$$

3) Shifting of monthly volumes across monthly and annual gaps (effectively only changes pumping at the end and beginning months of gapped years, as values are summed annually).

$$((\text{End of Month Serial}_{n-1} - \text{Serial}_{n-1}) / (\text{Serial}_n - \text{Serial}_{n-1})) * Qn = Q_{n-1\ portion}$$

$$((\text{Serial}_n - \text{End of Month Serial}_{n-1}) / (\text{Serial}_n - \text{Serial}_{n-1})) * Qn = Q_{n\ portion}$$

4) Calculation of annual pumping:

$$Q_n + Q_{n+1} + Q_{n+2} + Q_{n+n} = Q_{total} \text{ for given year}$$

SPNRD pumping was calculated per well, with no additional distribution. Months were determined to be active or inactive using the process described for NPNRD.

ASSUMPTIONS

Several assumptions were made in the processing of the NRD meter records. They include:

1) Wells tied to the same industrial use or certification were pumped equally.

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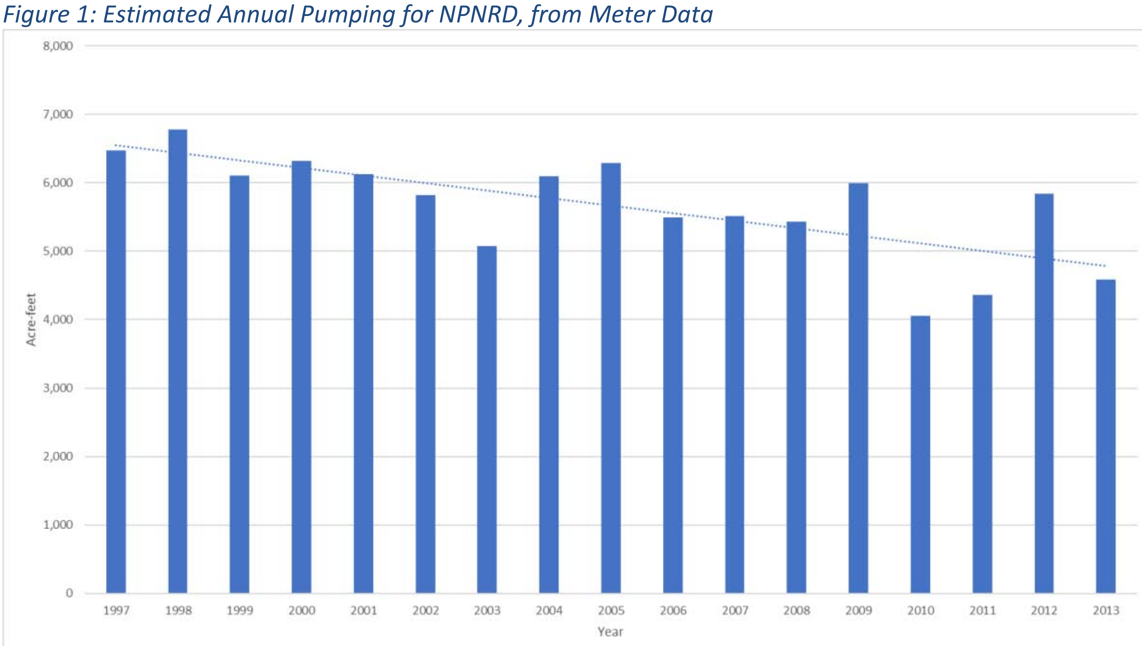
2) Gaps in TFM readings represent a pumping period if the first new reading differs from the previous reading; pumping is assumed to have occurred at a constant daily rate during the gap.
3) NDNR completion and abandonment dates reasonably approximate first and last use dates for the non-metered period, unless noted in discussion with each NRD or the well owner (in the case of industrial survey wells and those owned by Nebraska Public Power District [NPPD]).

RESULTS

Pumping for NPNRD was generally less than the annual pumping estimated for 1997, with an average annual volume 14% lower (approximately 855 AF). Large users generated most of the variability in annual volumes, with Western Sugar wells driving decreases in 2003, 2010, and 2011.

Figure 1: Estimated Annual Pumping for NPNRD, from Meter Data



Pumping for SPNRD was generally greater than the annual pumping estimated for 1997, with an average annual volume 2% greater (approximately 18 AF). Variability in the meter record was largely attributed to pumping by the City of Kimball, including declines in 2003 and 2011.

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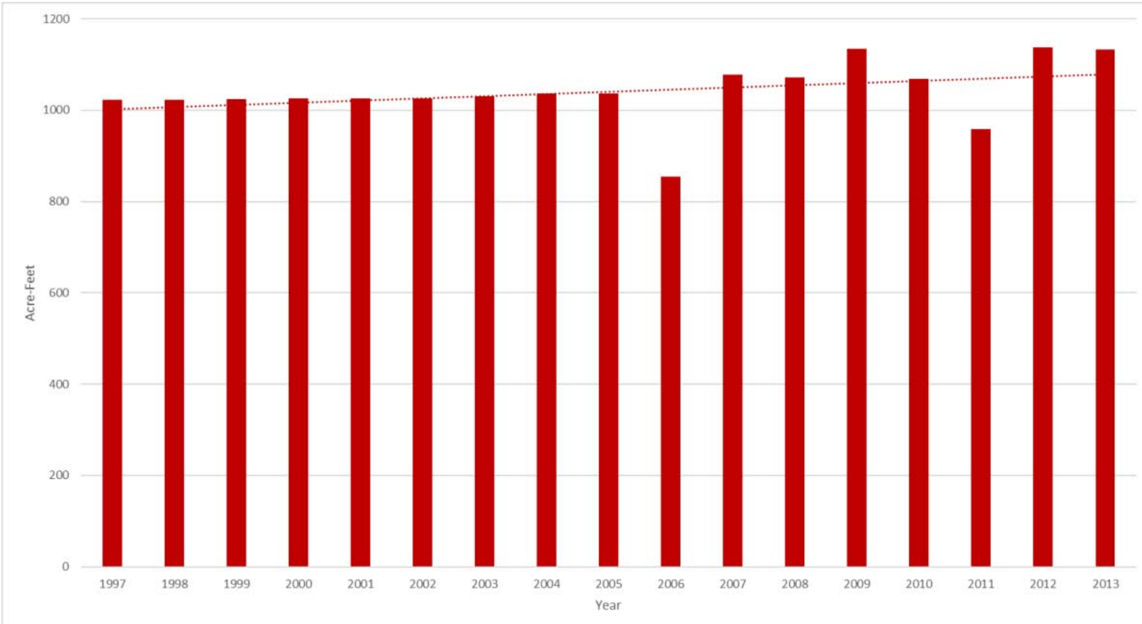
Figure 2: Estimated Annual Pumping for SPNRD, from Meter Data



CAPACITY DATA

METHOD

The statewide well registration database was retrieved as a shapefile from the DNR web portal (https://dnr.nebraska.gov/data/groundwater-data). Wells were isolated from the database for both NRDs using the "Commercial" use identification tag and NRD name. Each well was then assigned to an industrial category using the owner's name and description, with each category having an associated consumptive use estimate. This process sought to adapt the methodology described in "Municipal and Industrial Pumping" prepared by The Flatwater Group, Inc, using the per capacity pumping estimates defined in Appendix C. The assignation of industrial classes in North Platte and South Platte NRDs was subjective and cursory, and the results of the estimates calculated with this method may vary if the well classifications were otherwise defined.

- A total of 115 commercial wells were identified in NPNRD.
- A total of 80 commercial wells were identified in SPNRD.

Well capacity information was compiled monthly for each industrial class using well completion and decommission dates to denote active and inactive periods for each well. The same process as detailed for the meter data method was used. Pumping was then estimated using the associated per capacity pumping values. Monthly estimates were converted to annual averages for final analysis. Initially, a large portion of pumping in NPNRD was attributed to 15 wells owned by NPPD. Following communication with Jeff Schafer of NPPD, only one well was determined to be active during the modeling period. He reported that the 14 other wells were believed to be last used in 1986, though they were not abandoned until 2003, and were subsequently removed from the analysis. The remaining well was maintained for domestic and miscellaneous use. However, the original capacity data was maintained in the dataset, as the well's new capacity value is unknown.

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The process for calculating and distributing pumping is described with the following calculations:

1) Total monthly capacity summed by industrial classification:

$$(C_1 + C_2 + \ldots C_n) = C_t$$

2) Monthly capacity per classification converted to annual average:

$$(C_{t1} + C_{t2} + \ldots C_{t12}) \div n = C_{avg}$$

$$C_{avg} * \text{average per capacity pumping estimate} = P \text{ per class}$$

3) Annual pumping per class summed to provide annually estimated pumping per NRD:

$$(P_1 + P_2 + \ldots P_n) = P \text{ for given year}$$

As this method was initially analyzed for comparison purposes, the analysis did not include distribution of annual pumping back to individual wells. If this dataset is chosen, the same method of distribution as was used in the meter data method would be utilized.

ASSUMPTIONS

Several assumptions were made in the processing of the NRD capacity records. They include:

1) Well completion and decommission/abandonment dates are a fair representation of actual pumping periods.
2) Industrial classification for wells is a fair approximation of actual well use.
3) Average per capacity pumping values are a fair estimate of actual pumping.

RESULTS

Pumping for NPNRD was generally greater than the annual pumping estimated for 1997, with an average annual volume 3% higher (approximately 196 AF). Variability in pumping was largely driven by the ethanol and small business classes.

Figure 3: Estimated Annual Pumping for NPNRD, from Capacity Data

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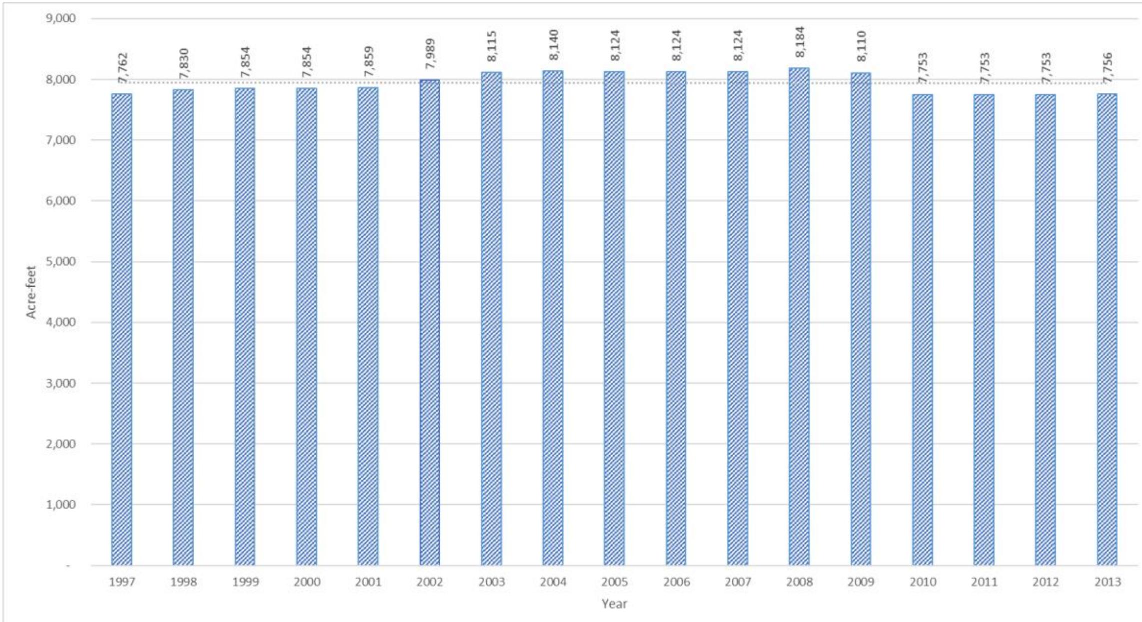
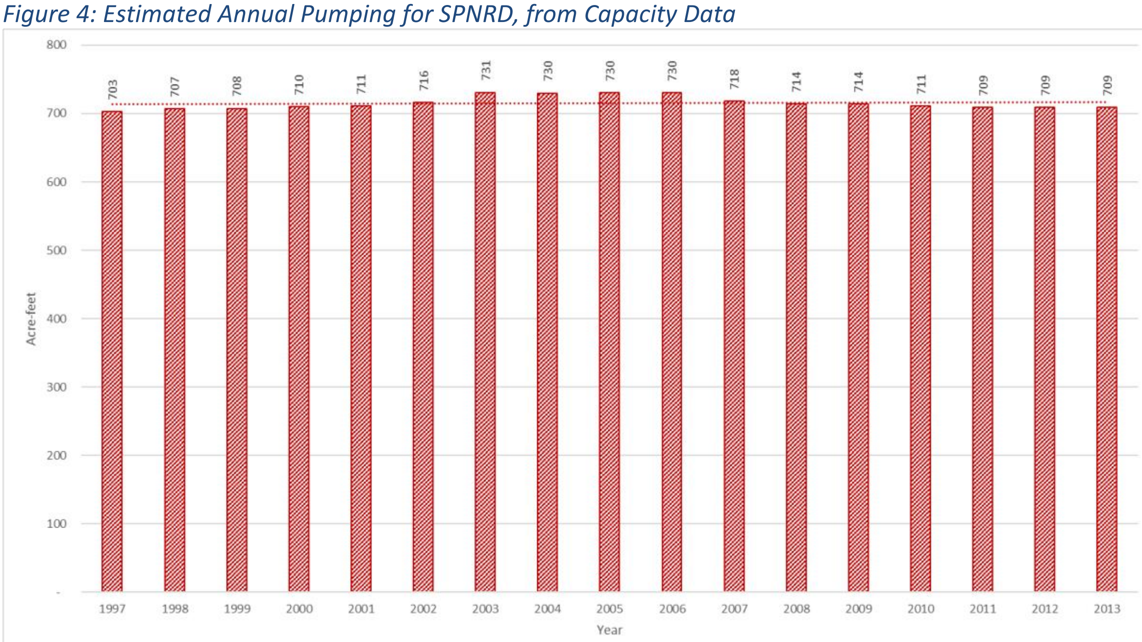


Pumping for SPNRD was generally greater than the annual pumping estimated for 1997, with an average annual volume 1% greater (approximately 13 AF). Variability in the pumping was largely driven by the sand and gravel class.

Figure 4: Estimated Annual Pumping for SPNRD, from Capacity Data



CONCLUSIONS AND RECOMMENDATION

Several issues arose in a direct comparison of the methodologies. A review of well identification numbers and registration numbers between datasets revealed the following:

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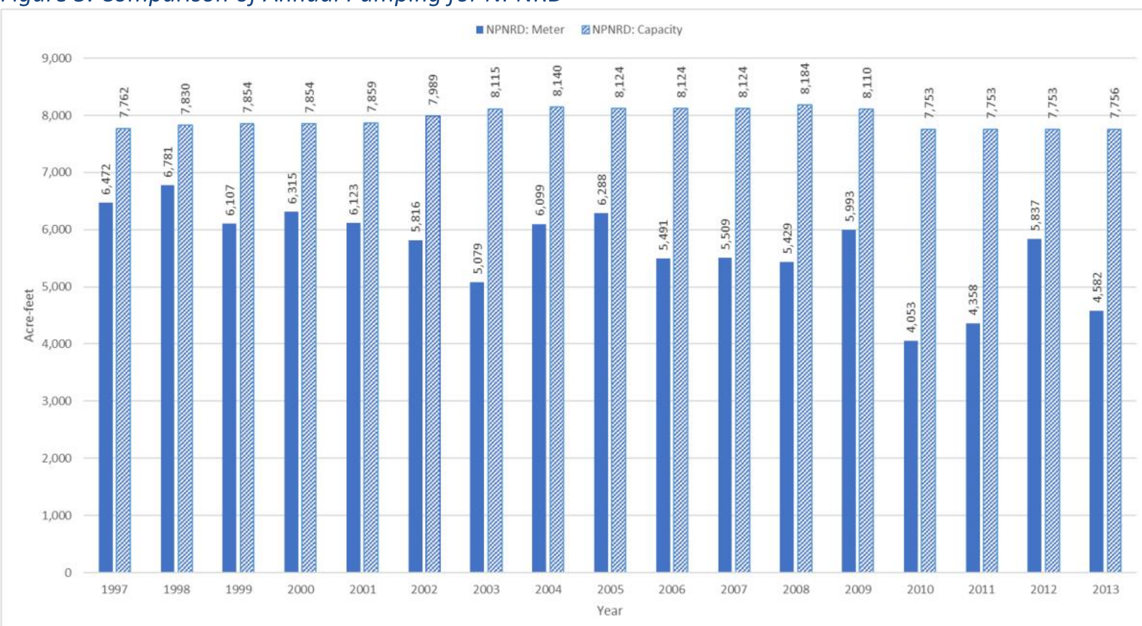
- Of the 115 wells identified in the capacity database for NPNRD, only 25 were present in the meter database; additionally, 17 wells identified in the meter database were not identified in the capacity database.
- Of the 80 wells identified in the capacity database for SPNRD, only 15 were present in the meter database; additionally, 25 wells identified in the meter database were not identified in the capacity database.
- Differences in total pumping estimates were significant.
  - NPNRD metered pumping estimates were an average of 71% of capacity estimates.
  - SPNRD metered pumping estimates were an average of 145% of capacity estimates.
- Differences in pumping trends were also noticeable in NPNRD.

NPNRD realized an average 14% decrease in annual pumping in the metered analysis, and an average 3% increase in annual pumping in the capacity analysis.

Figure 5. Comparison of Annual Pumping for NPNRD



SPNRD realized an average 2% increase in annual pumping in the metered analysis, and an average 1% increase in annual pumping in the capacity analysis.

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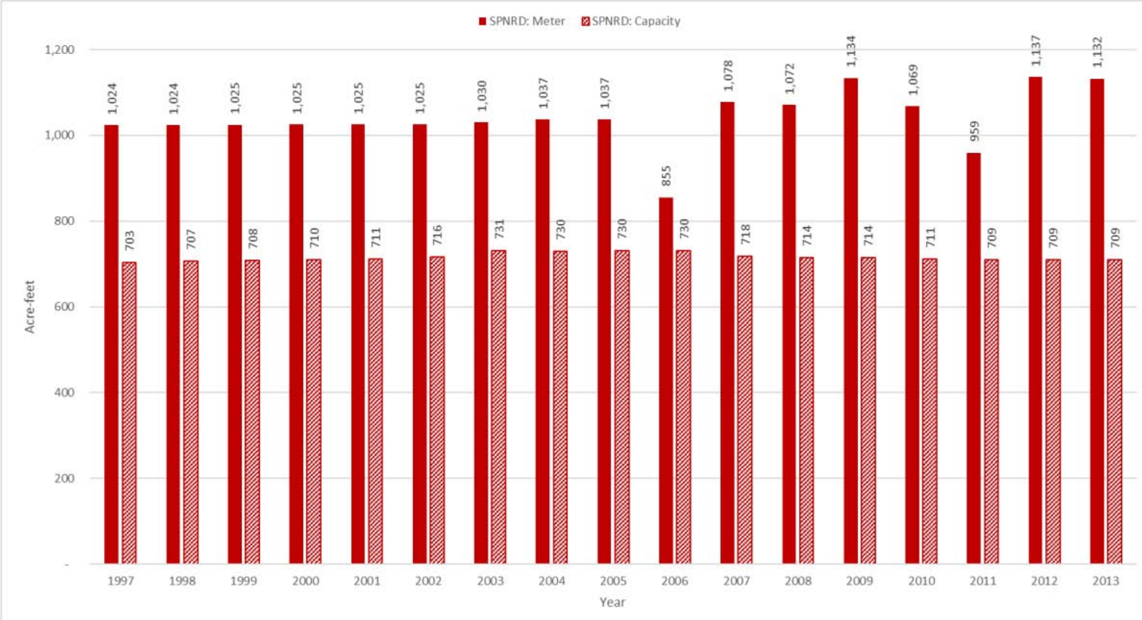
Figure 6. Comparison of Annual Pumping for SPNRD



Each methodology may include unique weaknesses derived from a lack or abundance of data that fails to accurately reflect actual pumping:

- Metered data may over- or underestimate pumping, especially in non-metered years and for certifications/wells with few records.
- Capacity data may over- or underestimate pumping, especially in the case of inaccurate abandonment dates; per capacity pumping estimates were also not determined for the area of interest in this analysis, with the possibility that the existing estimates fail to capture differences in regional industrial use or the presence of other industrial classes.

Differences in wells represented between datasets may be the result of differences in classification between the NRD and DNR database. Wells may be designated dual use, or temporarily transferred, in the NRD database and this change may not be represented in the DNR data. Well use may also vary for climactic, economic, or other reasons, which likely is not represented in the current per capacity pumping estimates. For these reasons, and the addition of future meter data collection by the NRDs, it is ARI's recommendation that a method utilizing the metered data in the Robust Review will most accurately reflect current and future industrial use.

Memo

Adaptive Resources, Inc.

To: POAC Technical Committee
From: Thad Kuntz, P.G. and Joe Reedy, G.I.
CC:
Date: 7/18/2018
Re: Addendum A: Robust Review: Industrial Pumping – Processes and Data Flow

Adaptive Resources, Inc. (ARI) is providing this document as an addendum to the final Robust Review industrial pumping dataset and associated memo report; Industrial Pumping Analysis, Robust Review Task: Post 1997 Development – Municipal/Industrial Pumping and Excess Flow Recharge, dated July 18, 2018 addressed to John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition by Thad Kuntz, P.G. and Joe Reedy, G.I. This document seeks to provide insights into the gathering and analysis of industrial and commercial data, specifically addressing changes to the scope of data and processing methods from previous iterations of the analysis and the differences they engender. It represents a short summary of the notes of ARI staff. The full report should be referenced for the final and complete methodology.

The initial Industrial Pumping information relied solely upon two datasets: the North Platte Natural Resources District (NRD) industrial pumping database, and the South Platte NRD industrial pumping database. Both databases include information compiled from industrial flow meters within the Districts. The analysis utilized similar calculations as described in the final report, whereby pumping records were converted to annual volumes, pumping averages were used to fill missing data, and pumping was then distributed monthly. The initial process indicated that South Platte NRD had relatively little industrial pumping and that the volume generally decreased through time. It also indicated that North Platte NRD industrial pumping generally increased through time. Both datasets displayed limited variability in early time data, reflecting the introduction of flow meters in the mid-2000's and the use of averages prior to that.

Following the initial analysis and discussion with the Technical Committee, the datasets were expanded, and slight changes were made to data processing. A review of included data was conducted with staff from both NRDs and both datasets were expanded to include additional wells or pumping records. The South Platte NRD dataset was expanded to include dual-use wells that had a dedicated industrial meter, increasing the number of wells represented in the analysis by a product of four. The North Platte NRD dataset was expanded to include additional pumping for existing wells and to correct for transcription errors in the original dataset that had decreased pumping volume. Additionally, the datasets were expanded to include pumping reported in the 2008 DNR Industrial Survey. The inclusion of Industrial Survey data resulted in additional pumping records for two existing industries, and one additional well in North Platte NRD. Data processing was modified to include the Industrial Survey data, which was reported annually.

As a result of these revisions, modeled pumping in South Platte NRD increased by an order of magnitude and the historical trend reversed, with a slight increase in pumping over time. Modeled pumping in North Platte NRD also increased, with the historical trend reversed (possibly due to the inclusion of additional historical data from the Industrial Survey) and pumping decreasing

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through time. The expanded datasets also displayed increased variability, especially in late time, possibly indicating a more realistic representation of industrial use.

Finally, an ancillary analysis of the state well registration database was conducted. Pumping capacity data for industrial wells in North Platte NRD represents a larger volume of pumping than is seen in the NRD meter database. However, following communication with some high-volume industries identified in the industrial dataset (namely NPPD), multiple wells were identified that had been abandoned prior to the modeling period. These wells were removed from the analysis, significantly decreasing pumping. South Platte NRD capacity data was significantly lower than the pumping represented in the meter database. This may indicate that temporary dual-use permits are not represented in the registration data. The capacity data also exhibits significantly less variability through time. An exhaustive analysis of wells in the registration database was not conducted, so it is unknown how many wells may be overrepresented due to failures in reporting. Additionally, wells that are classified as industrial to the State may be classified differently by each NRD (e.g., CAFO) and may not be represented in their databases.

A.1.10 Memorandums on NPNRD and SPNRD Ground Water Only Retirements

Memo

Adaptive Resources, Inc.

To:	John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition
From:	Thad Kuntz, P.G.
CC:	
Date:	12/3/2018
Re:	Robust Review Project: NPNRD and SPNRD Ground Water Only Retirements

Introduction

Adaptive Resources, Inc. (ARI) has compiled the retirements included in the baseline model run of the Western Water Use Management Modeling (WWUMM) for the Robust Review Project Analysis (RRPA). This memo summarizes information on permanent and temporary retirements incorporated in the land use datasets. The permanent retirements encompass those implemented by either the North Platte Natural Resources District (NPNRD) or South Platte Natural Resources District (SPNRD). The temporary retirements include those implemented through the CREP, CRP, and EQUIP federal programs within NPNRD.

Retired Ground Water Only Lands

The land use dataset created for the WWUMM incorporated ground water only lands that were either temporarily or permanently retired within NPNRD or SPNRD. In the land use dataset, irrigated land use retirements are simulated by removing the irrigated land encompassed by the retirement from the irrigated land use dataset. These lands are added to the dryland land use dataset where they are attributed with information such as crop type using the same process as other non-irrigated lands. For more information on how the WWUMM land use was created, refer to the SPNRD's website of Western Water Use Management Modeling Information (Link), Western Water Use Management Model Irrigated and Dryland Assessment by Leonard Rice Engineers, May 2012 (Link) and the Western Water Use Management Modeling Land Use Dataset Update through 2013, Memorandum to the Western Water Use Management Modeling Joint Board by Thad Kuntz P.G. and Heath Kuntz, April 2016 (Link).

The RRPA utilized the WWUMM ground water model as the initial model to construct the baseline model run which also simulates the irrigated land use retirements. Additionally, the commingled and surface water only retirements are also included in the WWUMM land use dataset, however, these retirements are not being analyzed in this phase of the RRPA.

Table 1 provides the annual and cumulative retired ground water only land information within NPNRD. Table 2 provides the cumulative permanent and temporary retired ground water only land information within NPNRD. Table 3 provides the annual and cumulative retired ground water only land information within SPNRD. In SPNRD, only permanent retirements have been completed. Map 1 and 2 show the locations of the retired ground water only lands within NPNRD and SPNRD, respectively.

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Table 1: Annual and Cumulative Retired Ground Water Only Lands within NPNRD (Acres)

Year	Annual Retired Acres	Cumulative Retired Acres
2002	42.5	42.5
2003	116.4	158.9
2004	61.6	220.4
2005	155.6	376.1
2006	872.2	1248.2
2007	479.1	1727.3
2008	238.6	1966.0
2009	-163.2	1802.8
2010	439.6	2242.4
2011	458.3	2700.7
2012	192.1	2892.8
2013	249.0	3141.9

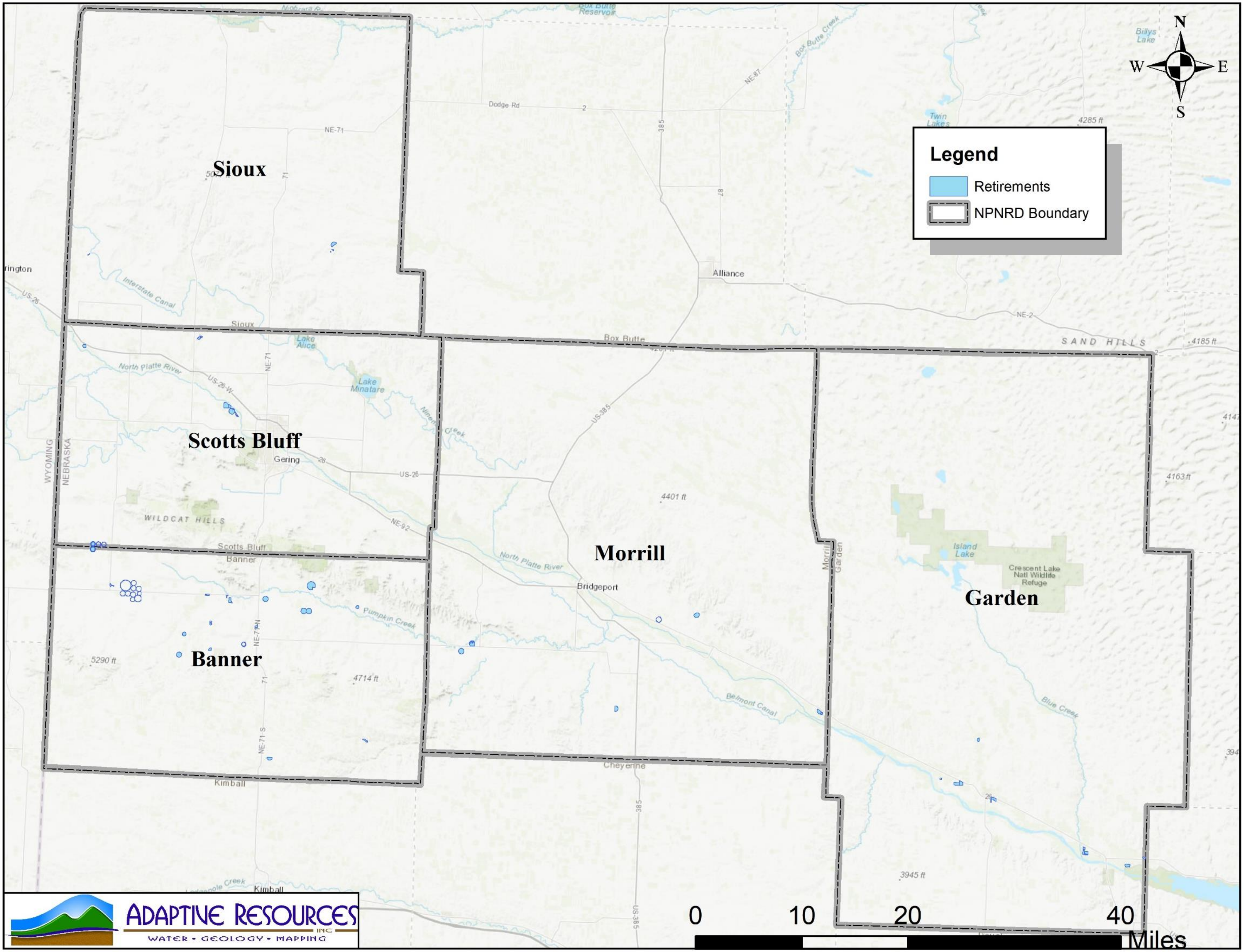
Table 2: Cumulative Permanent and Temporary Retired Ground Water Only Lands within NPNRD (Acres)

Year	Permanent Acres	Temporary Acres	Total Acres
2002	0.0	42.5	42.5
2003	116.4	42.5	158.9
2004	116.4	104.1	220.4
2005	116.4	259.7	376.1
2006	611.5	636.8	1248.2
2007	949.7	777.6	1727.3
2008	1187.8	778.2	1966.0
2009	1216.5	586.2	1802.8
2010	1227.5	1014.9	2242.4
2011	1258.5	1442.2	2700.7
2012	1309.7	1583.2	2892.8
2013	1426.0	1715.8	3141.9

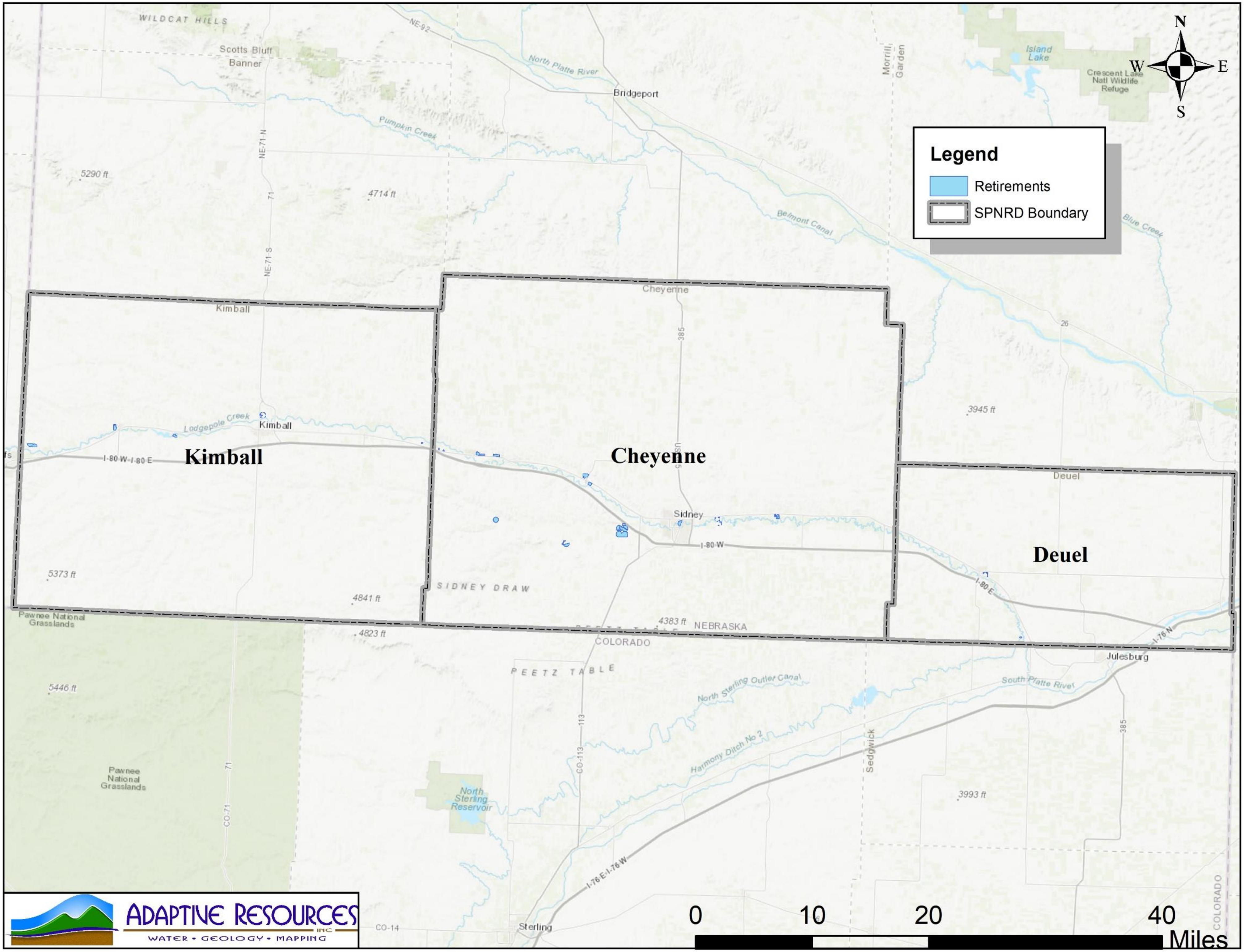
Table 3: Annual and Cumulative Retired Ground Water Only Lands within SPNRD (Acres)

Year	Annual Retired Acres	Cumulative Retired Acres
2007	585.1	585.1
2008	328.8	913.9
2009	138.9	1052.8
2010	176.1	1228.9
2011	59.6	1288.4
2012	99.0	1387.4
2013	0.0	1387.4

Map 1: Retired Ground Water Only Lands within NPNRD



Map 2: Retired Ground Water Only Lands within SPNRD



A.1.11 Memorandum on NPNRD and SPNRD Canal Excess Flow Diversion, Recharge Analysis Comparison, and Canal Loss Recommendation

Memo

Adaptive Resources, Inc.

To: John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition

From: Thad Kuntz, P.G., Joe Reedy G.I.T., and Jason Yuill

Date: 03/10/2017

Re: Robust Review Analysis: NPNRD and SPNRD Canal Excess Flow Diversion, Recharge Analysis Comparison, and Canal Loss Recommendation

INTRODUCTION

On January 23, 2017, the POAC Technical Committee (TC) requested that Adaptive Resources, Inc. (ARI) provide a technical discussion of differences between the Robust Review (RR) and the January 2013 Department of Natural Resources (DNR) Technical Memorandum (TM) titled Upper Platte River Recharge and Flood Mitigation Demonstration Project: Part of the Conjunctive Management Toolbox. Additionally, during an analysis completed for SPNRD, ARI discovered several discrepancies within the TM's datasets, processes, and methodology that the POAC TC should consider. The TM describes a methodology to quantify accretion credits from the excess flow diversions into canal recharge that each NRD can expect. The Canal Recharge Analysis task that is part of RR is designed to refine the accretion credit estimates by utilizing the Western Water Use Management Modeling (WWUMM) and COHYST Modeling and will be completed under that scope of work.

2011 Canal Excess Flow Diversion Review

During the spring and fall of 2011, high river flows occurred due to significant snowpack runoff from the Rocky Mountains. Consequently, emergency action was taken to divert water into canals to alleviate flood flows and recharge water along the North Platte River, South Platte River, and Platte River. Irrigation districts and canal companies that were amenable and able to participate were paid by the NRDs and DNR to divert the water to recharge local aquifers, and in exchange, accretion credit was obtained by each NRD for depletion offset. For the accretion credits to be considered valid, no irrigation could take place during the diversion of the flood flows. Additionally, the NRDs or DNR recorded the amount and total days that diversion occurred in each canal. In the case of the Western Irrigation District (WID), recharge pits were utilized to recharge water in addition to the canal itself.

Outline of Data Obtained and Compiled:

- Headgate diversion records were collected by DNR using recording devices
- DNR or NRD personnel collected surface return flow spill measurements
    - Typically, data was collected manually at varying times (days or weeks apart)
- Recharge pit diversions were collected using staff gages or flowmeters

As discussed in the TM, some diversions and spills were not measured.

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2013 Technical Memorandum Analysis Review

The TM's Analysis used the following equation for calculating canal loss as a percentage of the diverted excess flows:

$$Canal\ Loss\ \% = \left(1 - \frac{rate\ measured\ at\ spill}{daily\ diversion\ rate}\right) \times 100$$

The calculation of the Canal Loss percentage was completed on days that a canal had both diversion and return flow measurements. The resulting daily calculations were averaged to determine a recharge rate for each canal. Model estimates (WWUMM or COHYST) of canal recharge were utilized for canals that did not have return flow spill measurements.

Once the average recharge rate is determined, it is multiplied by the total amount of excess flow diversion completed by the canal. The total amount of recharge is then lagged back to a river or stream using the PBHEP zone's response functions that represent monthly return flow patterns that were developed using the Jenkins Method analytical equation.

Issues with the Technical Memorandum's Analysis

In 2015, ARI conducted an excess flow recharge and accretion credit analysis for SPNRD. Completing that analysis provided insight to refine the calculation of excess flow recharge estimates and put forth complications with the TM methodology, associated datasets, and processes.

Data obtained for the analysis were provided by SPNRD and DNR and include diversion dates for WID, diversion dates for SPNRD and TPNRD recharge pits along WID, diversion rates, spill rate measurements, and canal loss estimates. The WID excess flow events were recorded in the spring and fall of 2011, fall of 2013, and spring of 2014. SPNRD provided the following WID diversion dates of the excess flows:

- April 10 – June 1, 2011
- September 1 – November 14, 2011
- September 30 – October 27, 2013
- June 11 – July 8, 2014

Additionally, SPNRD, TPNRD, and the TM provided the total amount of pit recharge that occurred along WID per event.

Western Irrigation District Error and Differences in Total Diversion Days

Following a review of initial recharge estimates within the TM, it was discovered that the data provided was identical to that of Kearney Canal. Consequently, new diversion data for WID was requested from DNR on 12/08/2014 and 07/02/2015 and was determined that the data used for WID was the data for Kearney Canal. The excess flow diversion dates maintained by SPNRD and the new diversion data obtained from DNR confirmed the original TM data was in error.

Western Irrigation District Recharge Pit Calculation Error

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The TM's calculation of canal loss for WID used the difference of the canal diversion and return flow spill measurements to determine total canal recharge. However, recharge pits were also employed along WID canal and were not considered in the calculation. This caused the TM methodology to overestimate the recharge. To mitigate this issue, the TM's canal loss calculation method should be altered to account for the water diverted into the recharge pits.

The analysis for SPNRD calculated the canal loss based upon their and TPNRD's information. These NRDs visited and tracked these sites and provided information that water was diverted into the pits through the final day of excess flow diversion. During the spring 2011 event, the WID diversion data and the number of total days each pit received water were used to complete the canal loss calculation to incorporate the recharge pits. The calculation was carried out starting on the last day of excess flow diversion and moved backward in time until the correct number of diversion days for each pit had been achieved.

Using additional SPNRD records, it was assumed that all pits diverted for the entire canal excess flow diversion events of 2013 and 2014 events. The excess flow diversion in 2014 occurred during the irrigation season, so only recharge into the pits was credited.

Possible Additional Refinements

During the completion of the SPNRD analysis, some additional discrepancies were identified in the data, and several additional changes were made to the process.

- Differences in diversion data obtained from DNR at different times were discovered; discrepancies also existed between data in the TM and data requested from DNR after the publication of the TM. Differences in preliminary and final data may account for this issue. Potentially, NRDs may need access to the method utilized by DNR for adjusting preliminary/raw diversion records to ensure a more accurate estimate of the canal recharge that the NRDs can use for planning purposes and before the payment to the irrigation district or canal company is completed.
- Adjustments in diversion data and the removal of pit diversion volumes sometimes resulted in negative canal recharge values. These issues require a more extensive investigation of the data and methods.
- For some excess flow events, canal loss was estimated over a relatively extended period but with few return flow records. In a few cases, only one return flow measurement was obtained. Because of the minimal return flow measurements, the average canal loss estimate may not represent the individual canal's actual average for the entire event.

Robust Review Analysis Review

During the final edits to the RR scope of work, the POAC TC decided that the Canal Recharge Project task utilize the WWUMM and COHYST model's calibrated canal leakage estimates for each canal to determine the total amount of recharge that occurs during excess flow diversion events. Simply, the analysis will remove these diversions and subsequent canal recharge from the modified modeling for each canal to determine the accretive effects. Total recharge for WID

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will need to account for the recharge pits by removing the total pit diversions from the overall headgate diversions before the calculation of the canal recharge using the models.

Robust Review Analysis Discussion
As provided above, the TM's analysis to determine the amount of canal recharge that occurs differs from the RR design. The RR scope of work did not incorporate the return flow spill measurements for each canal as part of the analysis. The POAC TC will need to determine if this data is appropriate to utilize or if the calibrated modeled estimates of canal leakage are suitable.

Our recommendation is to independently review each canal during each diversion event to determine whether the calculated canal loss TM's methodology, the modeled estimates of irrigation season canal loss, or a combination of the two are appropriate. While this is time intensive and somewhat subjective, a one size fits all recommendation is not possible because either the TM's canal loss calculation or the modeled estimates may not be appropriate. Table 1 is an evaluation of each canal within WWUMM area and provides an updated version of TM calculated canal loss using the finalized DNR diversions, the number of spill measurements, modeled canal loss, our recommendation of the canal loss to use, and an explanation of the criteria we used to determine the recommended canal loss. We completed this for the WWUMM area due to our familiarity with the system. However, for the COHYST area, we recommend that someone with more extensive knowledge of that system complete a similar evaluation.

Memo

Table 1: WWUM Modeling Area 2011 Spring Assessment of Canal Loss Calculations, Recommended Canal Loss, and Explanation

Canal	Updated TM Canal Loss %	Number of Spill Measurements	Modeled Canal Loss %	Recommended Canal Loss % to Use	Recommended Canal Loss %	Explanation of the Criteria for the Recommendation
Pathfinder	40%	1	55%	Modeled	55%	There was only a single spill measurement taken at the Pathfinder Spill. However, there is no data for the other Pathfinder spill locations to determine if there were additional spills.
Farmers	45%	3	49%	Modeled	49%	There were three spill measurements. However, two measurements only recorded spills at Red Willow Creek at the end of the canal, and one measurement measured Winters Creek and Red Willow Creek. We personally know they spilled some water into Nine Mile Creek. The canal has several other spills points, and the dataset does not provide any information on whether spills occurred at these locations.
Enterprise	69%	3	42%	Modeled	42%	There were three spill measurements with decent distribution during the excess flow diversion. However, one measurement recorded spill at Tub Springs Creek and two measurements measured at Winters Creek at the end of the canal. There is no additional information on whether the Tub Springs or Winters Creek spills were active during each other measurement.
Minatare	24%	4	41%	Measured	24%	Minatare Canal had a decent number of spill measurements between 4-5-2011 and 4-26-2011. The canal diverted between 4-1-2011 and 4-30-2011. This is an acceptable resolution to determine the canal loss.
Castle Rock	41%	3	41%	Average of Measured and Modeled	41%	Castle Rock Canal had a decent number of spill measurements between 4-13-2011 and 4-26-2011. However, the canal diverted from 4-3-2011 and 5-3-2011. Because of the narrow date range of the spill measurements the measurements were averaged with the modeled estimate of canal loss.
Chimney Rock	45%	4	42%	Measured	45%	Chimney Rock Canal had a decent number of spill measurements between 4-4-2011 and 4-26-2011. The canal diverted between 4-1-2011 and 5-1-2011. This is an acceptable resolution to determine the canal loss.
Nine Mile	96%	1	41%	Average of Measured and Modeled	68%	There was only a single spill measurement taken at Nine Mile Spill. However, with only one measurement on 4-21-2011, there is not sufficient data to determine if the canal leakage was realistic, so the measured and modeled data were averaged.
Belmont	53%	3	38%	Measured	53%	Belmont Canal had a decent number of spill measurements between 4-4-2011 and 4-20-2011. The canal diverted between 4-1-2011 and 5-1-2011. This is an acceptable resolution to determine the canal loss.
Lisco	24%	1	41%	Average of Measured and Modeled	33%	There was only a single spill measurement taken at Lisco Spill. However, with only one measurement on 4-19-2011, there is not sufficient data to determine if the canal leakage was realistic, so we averaged the measured and modeled data.
Central	25%	0	42%	Modeled	42%	There were no spill measurements taken for Central Canal. The spreadsheet associated with the TM provides an estimated number. However, the estimated number was ignored as well, and 25% was used. We disregarded both these numbers and used the modeled estimate for canal leakage.
Western	31%	11	37%	Corrected Measurements	31%	There were 11 measurements from 4-21-2011 through 5-31-2011 for Western Canal which is a decent resolution. To determine the canal loss, the original TM was corrected by using Western Canal's diversions instead of Kearney Canal's. Note: Contractually, 70% of the canal recharge goes to TPNRD and 30% goes to SPNRD
Western Canal Pits	100%	N/A	N/A	N/A	100%	TM assumed that all the recorded values were recharged at 100%

Memo

Table 2: WWUM Modeling Area 2011 Fall Assessment of Canal Loss Calculations, Recommended Canal Loss, and Explanation

Canal	Updated TM Canal Loss %	Number of Spill Measurements	Modeled Canal Loss %	Recommended Canal Loss % to Use	Recommended Canal Loss %	Explanation of the Criteria for the Recommendation
Minatare	17%	1	41%	Average of Measured and Modeled	29%	There was only a single spill measurement taken at the Minatare Canal spill. Because one measurement is not sufficient, the averaged measured and model data was used.
Castle Rock	45%	2	41%	Average of Measured and Modeled	43%	Castle Rock Canal had two measurements occurring on 10-10-11 and 10-17-11. Due to the limited number of measurements, the averaged measured and model data was used.
Chimney Rock	17%	2	42%	Average of Measured and Modeled	30%	Chimney Rock Canal had two measurements occurring on 10-10-11 and 10-18-11. Due to the limited number of measurements, the averaged measured and model data was used.
Nine Mile	96%	0	41%	Modeled	41%	No measurements were taken in the fall at Nine Mile Spill, so the modeled canal loss was used.
Belmont	63%	2	38%	Average of Measured and Modeled	51%	Belmont Canal had two measurements occurring on 10-12-11 and 10-18-11. Due to the limited number of measurements, the averaged measured and model data was used.
Lisco	56%	2	41%	Average of Measured and Modeled	49%	Lisco had two measurements occurring on 10-12-11 and 10-18-11. Due to the limited number of measurements, the averaged measured and model data was used.
Central	26%	2	42%	Average of Measured and Modeled	34%	Central had two measurements occurring on 10-11-11 and 10-17-11. Due to the limited number of measurements, the averaged measured and model data was used.
Winters	1%	2	41%	Average of Measured and Modeled	21%	Winters had two measurements occurring on 10-11-11 and 10-17-11. The spill measurement on 10-17-11 created a negative canal loss measurement and was ignored. Consequently, 1% loss was used as the measured amount. Due to the limited number of measurements, the averaged measured and model data was used.
Western	38%	3	37%	Measured	38%	Western Canal had 3 measurements in the fall which occurred on 10-17-11, 10-5-11, and 11-9-11. The measurement from 11-9-11 was ignored because it was a negative value. Due to the limited number of measurements, the averaged measured and model data was used. Note: Contractually, 70% of the canal recharge goes to TPNRD and 30% goes to SPNRD
Western Canal Pits	100%	N/A	N/A	N/A	100%	TM assumed that all the recorded values were recharged at 100%

Memo

Table 3: WWUM Modeling Area 2013 Fall Assessment of Canal Loss Calculations, Recommended Canal Loss, and Explanation

Canal	Updated TM Canal Loss %	Number of Spill Measurements	Modeled Canal Loss %	Recommended Canal Loss % to Use	Recommended Canal Loss %	Explanation of the Criteria for the Recommendation
Western	31%	3	37%	Duplicate Measurements	31%	Because there were no measurements for fall 2013 for Western Canal, the same canal loss % for fall 2011 was used. Note: Contractually, 70% of the canal recharge goes to TPNRD and 30% goes to SPNRD
Western Canal Pits	100%	N/A	N/A	N/A	100%	TM assumed that all the recorded values were recharged at 100%

B.1 Evaluation of Livestock Uses

B.1.1 Cattle Analysis- COHYST

THE FLATWATER GROUP INC.

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MEMORANDUM

To: POAC Technical Committee and Administrators

From: Marc Groff

Date: 8/7/2017

Re: Robust Review Cattle Number Summary – COHYST Modeling Area

Executive Summary

Task 1 of the current Robust Review Scope of Work (SOW) includes developing model runs which would incorporate changes to cattle on feed numbers over the 1997 baseline condition. At the time the SOW was developed, there was concern that cattle numbers across the Robust Review modeling domain may have increased significantly enough between 1997 and 2013 to impact results from the modeling effort. Prior to developing model input files for this scenario, the technical team developed estimates of how consumption would change based on changes in cattle population from 1997. The primary data source for this estimation effort was National Agricultural Statistics Service (NASS). Unfortunately, NASS did not request information related to the number of cattle on feed as part of its 1997 survey; however, NASS has requested total cattle inventory numbers continuously from 1997 through 2013. For this reason, the consumption estimates for the COHYST region are based on changes to total cattle (including calves) population estimates. The consumption related specifically to cattle on feed would be some fraction of the total estimated numbers provided below in Table ES-1.

Table ES-1. Estimated Change in Annual Water Consumption From 1997 Baseline Condition (Acre-Feet)

NRD	Average Difference	High Value (Year)	Low Value (Year)
CPNRD	-297	102 (1999)	-610 (2004)
TBNRD	-22	78 (2007)	-101 (2003 & 2005)
TPNRD	52	176 (2013)	-44 (2003)

For context, the average annual estimated consumption by crops of pumped ground water between 1985 and 2010 within the Twin Platte NRD portion of the COHYST model alone exceeded 245,000 acre-feet per year. The magnitude of the differences summarized in Table ES-1 are not likely to be noticeable in the overall modeling results. **For this reason, it is recommended that modeling files related to identifying impacts resulting from changes to cattle on feed numbers not be developed for further analysis as part of the Robust Review.**

Introduction

Task 1 of the current Robust Review SOW includes developing model runs which would incorporate changes to cattle on feed numbers over the 1997 baseline condition. At the time the SOW was developed, there was concern that cattle numbers across the Robust Review modeling domain may have increased significantly enough between 1997 and 2013 to impact results from the modeling effort. Prior to developing model input files which would be designed to account for impacts related to change in cattle on feed numbers, the technical team developed estimates of the expected changes in consumption related to the changes in cattle populations. This memorandum documents the methods used to develop that estimate over the COHYST modeling area of Robust Review project domain.

Methods

To estimate changes to water consumption related to changes in cattle on feed numbers, the general approach used in this analysis was to estimate consumption as a function of population. In October of 2008, the Nebraska Department of Natural Resources (DNR) used a similar approach in developing a document which examined cattle population changes from 1992 through 2007. That work was based on population estimates from the National Agricultural Statistics Service (NASS) and also identified a daily water use rate for cattle of 7 gallons per head (gph) per day.

To maintain consistency with that past work, information from NASS was again used for this analysis along with the daily water use rate of 7 gph. Unfortunately, NASS did not request information specifically related to the number of cattle on feed as part of its 1997 survey. NASS has, however, continuously from 1997 through 2013 requested information on total cattle (including calves) inventory. This appears to be the information summarized in the 2008 DNR analysis and was selected for use in this analysis. Figure 1 provides a screen shot of the query submitted via the web to NASS which returned the information used for this analysis.

The NASS information is aggregated at a county level basis. To develop summaries of the information by NRD, it was assumed that the cattle population statistics represented within the NASS dataset were uniformly distributed across a county. Information to suggest a different distribution or specific locations within a county where the estimated cattle numbers were located was not available. Using the uniform distribution assumption, it was possible to estimate cattle populations by NRD based on the percentage of a given county located within a given NRD. The county population statistic was distributed based on the percentage of a given county's area within a given NRD. Figure 2 shows the respective boundaries of the COHYST modeling boundary, NRD boundaries, and county boundaries within the focus area of this memo. Standard GIS techniques were used to determine the percentage of a given county within a given NRD.

After estimating the annual total number of cattle (including calves) per NRD, the population change relative to 1997 was calculated and an annual estimated change in water consumption was computed by multiplying the change in the number of head times 7 gph and converting to units of acre-feet to be consistent with the units used in other publications. The specific formula used was:

Eqn 1: *Population Change * 7 gph/day * 3.06889E-06 Acre-Feet/gal * 362.25 days/year*

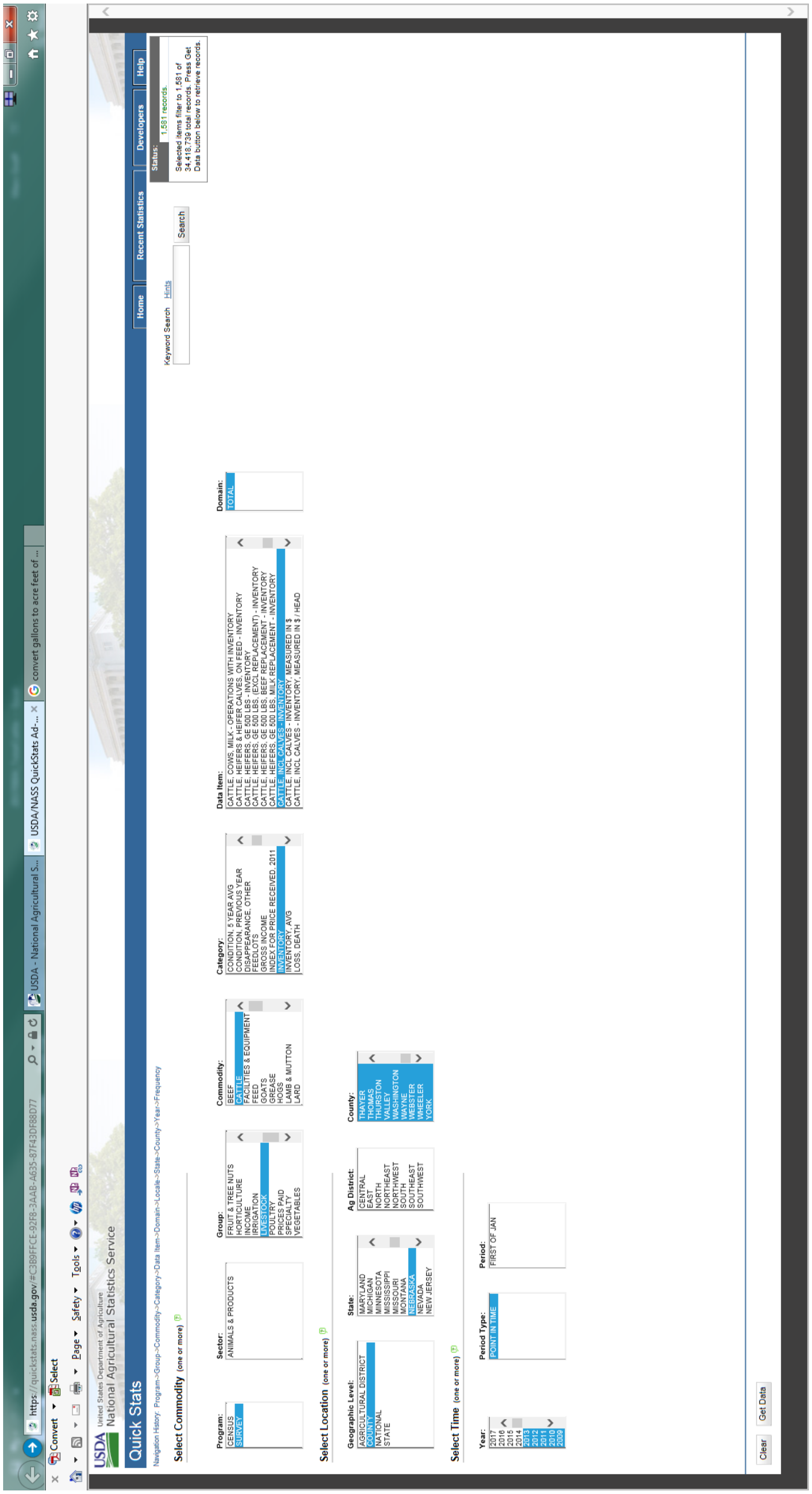

Figure 1: Web Query Screen Shot

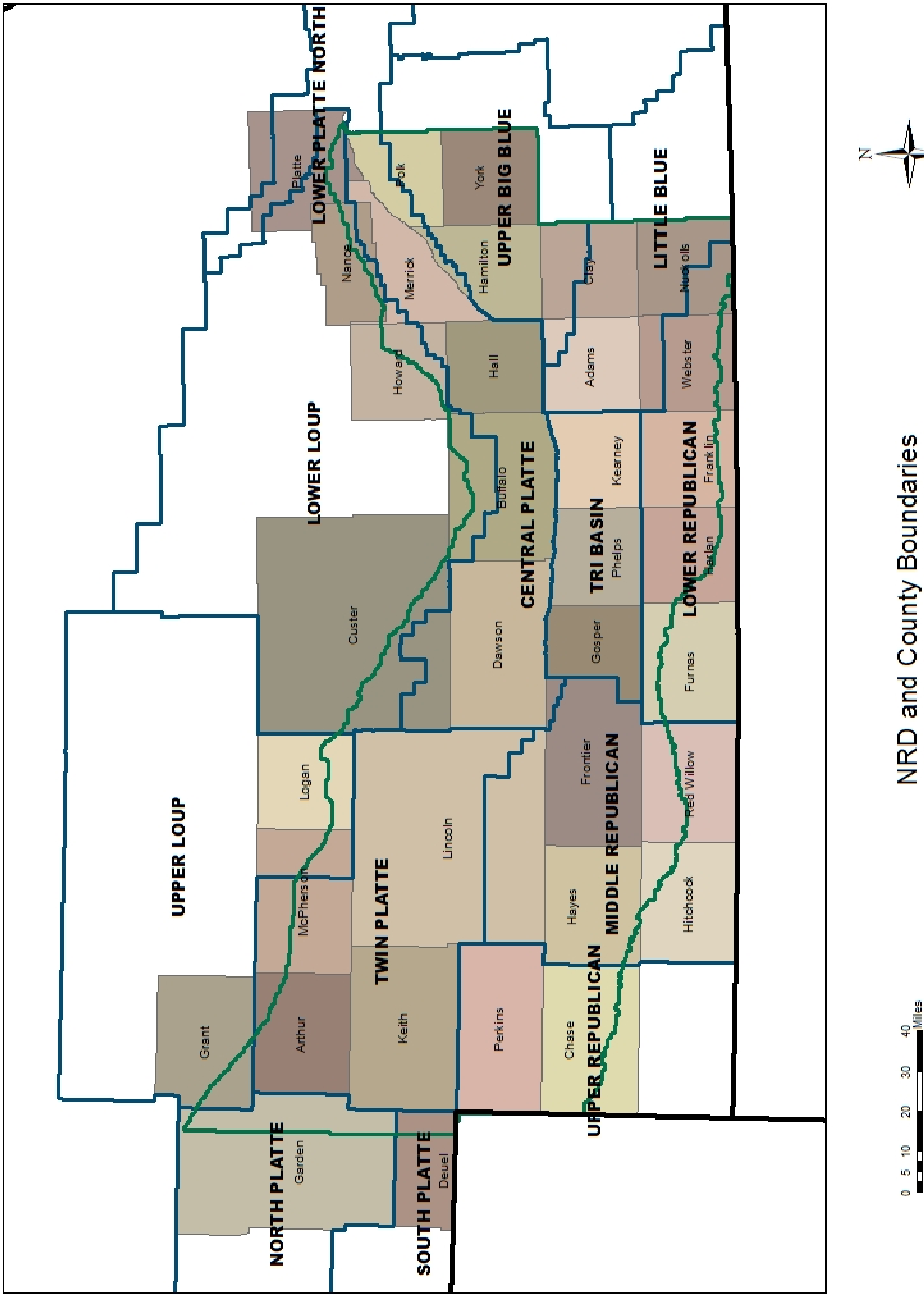

Figure 2: COHYST Model, County and NRD Boundaries

Results

Table 1 below summarizes the results of this analysis.

Table 1. Estimated Change in Annual Water Consumption From 1997 Baseline Condition (Acre-Feet)

NRD	Average Difference	High Value (Year)	Low Value (Year)
CPNRD	-297	102 (1999)	-610 (2004)
TBNRD	-22	78 (2007)	-101 (2003 & 2005)
TPNRD	52	176 (2013)	-44 (2003)

Table 1 was built up using the process described in the Methods section. Following are a series of tables which trace the process through those steps.

The results of the web query shown on Figure 1 for counties within the COHYST area of the Robust Review domain are shown on Table 2.

The estimates of cattle population by NRD developed from that information are shown on Tables 3-5. The percentages used to distribute each county's estimate to the NRD estimate is included on the table.

Table 6 lists the annual change in cattle populations by NRD from the 1997 baseline condition.

Table 7 lists the annual change in water use by NRD resulting from the cattle population changes shown on Table 6 and Eqn 1 discussed in the Methods section. The summaries presented above on Table 1 were taken from Table 7.

Table 2: Summary Of Nebraska Total Cattle Inventory (Including Calves) - Platte Basin COHYST Model Area

Source: Annual National Agricultural Statistics Service Surveys from 1997 through 2013

County	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ARTHUR	38,000	38,000	37,000	36,000	35,000	33,000	30,000	30,000	33,000	33,000	36,000	31,500	31,000	30,500	31,000	31,000	25,500
BUFFALO	116,000	116,000	118,000	116,000	114,000	106,000	103,000	100,000	100,000	106,000	108,000	100,000	98,000	98,000	98,000	100,000	105,000
CUSTER	285,000	292,000	294,000	292,000	292,000	282,000	285,000	277,000	279,000	290,000	306,000	300,000	295,000	290,000	290,000	300,000	290,000
DAWSON	250,000	253,000	256,000	252,000	251,000	240,000	215,000	213,000	212,000	227,000	237,000	220,000	215,000	215,000	215,000	220,000	240,000
FRONTIER	72,000	79,000	79,000	72,000	66,000	60,000	55,000	57,000	59,000	61,000	64,000	58,000	57,000	57,000	57,000	58,000	57,000
GOSPER	36,000	33,000	33,000	32,000	30,000	28,000	26,000	27,000	27,000	29,000	28,000	25,000	24,500	24,500	24,000	25,000	27,000
HALL	80,000	79,000	81,000	79,000	80,000	77,000	77,000	74,000	72,000	77,000	81,000	85,000	84,000	84,000	83,000	85,000	69,000
HAMILTON	40,000	42,000	39,000	38,000	41,000	44,000	46,000	43,000	43,000	43,000	39,000	32,500	32,000	31,500	31,500	32,000	41,000
HOWARD	73,000	74,000	75,000	78,000	80,000	76,000	72,000	70,000	73,000	79,000	79,000	82,000	80,000	80,000	80,000	81,000	80,000
KEARNEY	85,000	90,000	86,000	83,000	83,000	83,000	82,000	77,000	77,000	78,000	81,000	80,000	78,000	78,000	78,000	80,000	82,000
KEITH	78,000	80,000	75,000	72,000	69,000	64,000	58,000	56,000	54,000	55,000	53,000	54,000	53,000	52,000	52,000	54,000	55,000
LINCOLN	189,000	206,000	202,000	204,000	211,000	210,000	215,000	225,000	228,000	235,000	227,000	245,000	240,000	240,000	240,000	245,000	270,000
MCPHERSON	38,000	41,000	41,000	42,000	43,000	42,000	43,000	43,000	43,000	42,000	45,000	42,000	41,000	41,000	41,000	42,000	36,500
MERRICK	81,000	80,000	79,000	78,000	73,000	66,000	60,000	63,000	66,000	70,000	69,000	58,000	57,000	57,000	57,000	58,000	45,000
NANCE	43,000	41,000	39,000	38,000	37,000	36,000	35,000	37,000	39,000	40,000	37,000	33,500	33,000	32,500	32,500	33,000	28,000
PHELPS	158,000	165,000	164,000	163,000	163,000	162,000	158,000	163,000	162,000	168,000	180,000	175,000	175,000	170,000	170,000	175,000	165,000
PLATTE	85,000	86,000	82,000	80,000	80,000	80,000	80,000	80,000	85,000	89,000	101,000	120,000	120,000	120,000	120,000	120,000	125,000
POLK	65,000	64,000	65,000	67,000	65,000	60,000	56,000	55,000	58,000	62,000	68,000	78,000	77,000	76,000	76,000	78,000	69,000
Total	1,812,000	1,859,000	1,845,000	1,822,000	1,813,000	1,749,000	1,696,000	1,690,000	1,710,000	1,784,000	1,839,000	1,819,500	1,790,500	1,777,000	1,776,000	1,817,000	1,810,000

Table 3
Annual Estimated Head of Cattle within the Central Platte NRD

Year	BUFFALO	CUSTER	DAWSON	FRONTIER	HALL	HAMILTON	HOWARD	NANCE	PHELPS	PLATTE	POLK	Total
1997	74,240	31,350	250,000	71,280	79,200	3,600	6,570	40,420	18,960	3,400	27,300	606,320
1998	74,240	32,120	253,000	78,210	78,210	3,780	6,660	38,540	19,800	3,440	26,880	614,880
1999	75,520	32,340	256,000	78,210	80,190	3,510	6,750	36,660	19,680	3,280	27,300	619,440
2000	74,240	32,120	252,000	71,280	78,210	3,420	7,020	35,720	19,560	3,200	28,140	604,910
2001	72,960	32,120	251,000	65,340	79,200	3,690	7,200	34,780	19,560	3,200	27,300	596,350
2002	67,840	31,020	240,000	59,400	76,230	3,960	6,840	33,840	19,440	3,200	25,200	566,970
2003	65,920	31,350	215,000	54,450	76,230	4,140	6,480	32,900	18,960	3,200	23,520	532,150
2004	64,000	30,470	213,000	56,430	73,260	3,870	6,300	34,780	19,560	3,200	23,100	527,970
2005	64,000	30,690	212,000	58,410	71,280	3,870	6,570	36,660	19,440	3,400	24,360	530,680
2006	67,840	31,900	227,000	60,390	76,230	3,870	7,110	37,600	20,160	3,560	26,040	561,700
2007	69,120	33,660	237,000	63,360	80,190	3,510	7,110	34,780	21,600	4,040	28,560	582,930
2008	64,000	33,000	220,000	57,420	84,150	2,925	7,380	31,490	21,000	4,800	32,760	558,925
2009	62,720	32,450	215,000	56,430	83,160	2,880	7,200	31,020	21,000	4,800	32,340	549,000
2010	62,720	31,900	215,000	56,430	83,160	2,835	7,200	30,550	20,400	4,800	31,920	546,915
2011	62,720	31,900	215,000	56,430	82,170	2,835	7,200	30,550	20,400	4,800	31,920	545,925
2012	64,000	33,000	220,000	57,420	84,150	2,880	7,290	31,020	21,000	4,800	32,760	558,320
2013	67,200	31,900	240,000	56,430	68,310	3,690	7,200	26,320	19,800	5,000	28,980	554,830
% in NRD	64%	11%	100%	4%	99%	9%	9%	94%	12%	4%	42%	

Table 4
Annual Estimated Head of Cattle within the Tri-Basin NRD

Year	GOSPER	KEARNEY	PHELPS	Total
1997	36,000	85,000	158,000	279,000
1998	33,000	90,000	165,000	288,000
1999	33,000	86,000	164,000	283,000
2000	32,000	83,000	163,000	278,000
2001	30,000	83,000	163,000	276,000
2002	28,000	83,000	162,000	273,000
2003	26,000	82,000	158,000	266,000
2004	27,000	77,000	163,000	267,000
2005	27,000	77,000	162,000	266,000
2006	29,000	78,000	168,000	275,000
2007	28,000	81,000	180,000	289,000
2008	25,000	80,000	175,000	280,000
2009	24,500	78,000	175,000	277,500
2010	24,500	78,000	170,000	272,500
2011	24,000	78,000	170,000	272,000
2012	25,000	80,000	175,000	280,000
2013	27,000	82,000	165,000	274,000
% in NRD	100%	100%	100%	

Table 5
Annual Estimated Head of Cattle within the Twin Platte NRD

Year	ARTHUR	KEITH	LINCOLN	MCPHERSON	Total
1997	38,000	78,000	137,970	25,460	279,430
1998	38,000	80,000	150,380	27,470	295,850
1999	37,000	75,000	147,460	27,470	286,930
2000	36,000	72,000	148,920	28,140	285,060
2001	35,000	69,000	154,030	28,810	286,840
2002	33,000	64,000	153,300	28,140	278,440
2003	30,000	58,000	156,950	28,810	273,760
2004	30,000	56,000	164,250	28,810	279,060
2005	33,000	54,000	166,440	28,810	282,250
2006	33,000	55,000	171,550	28,140	287,690
2007	36,000	53,000	165,710	30,150	284,860
2008	31,500	54,000	178,850	28,140	292,490
2009	31,000	53,000	175,200	27,470	286,670
2010	30,500	52,000	175,200	27,470	285,170
2011	31,000	52,000	175,200	27,470	285,670
2012	31,000	54,000	178,850	28,140	291,990
2013	25,500	55,000	197,100	24,455	302,055
% in NRD	100%	100%	73%	67%	

Table 6
Annual Change in Total Head of Cattle From 1997 Basline Conditions

Year	Central Platte NRD	Tri-Basin NRD	Twin Platte NRD	3 NRD Area
1997	0	0	0	0
1998	8,560	9,000	16,420	33,980
1999	13,120	4,000	7,500	24,620
2000	-1,410	-1,000	5,630	3,220
2001	-9,970	-3,000	7,410	-5,560
2002	-39,350	-6,000	-990	-46,340
2003	-74,170	-13,000	-5,670	-92,840
2004	-78,350	-12,000	-370	-90,720
2005	-75,640	-13,000	2,820	-85,820
2006	-44,620	-4,000	8,260	-40,360
2007	-23,390	10,000	5,430	-7,960
2008	-47,395	1,000	13,060	-33,335
2009	-57,320	-1,500	7,240	-51,580
2010	-59,405	-6,500	5,740	-60,165
2011	-60,395	-7,000	6,240	-61,155
2012	-48,000	1,000	12,560	-34,440
2013	-51,490	-5,000	22,625	-33,865

Table 7
Estimated Annual Change in Water Consumption From 1997 Basline Conditions (Acre-Feet)

Year	Central Platte NRD	Tri-Basin NRD	Twin Platte NRD	3 NRD Area
1997	0	0	0	0
1998	67	70	128	264
1999	102	31	58	192
2000	-11	-8	44	25
2001	-78	-23	58	-43
2002	-306	-47	-8	-361
2003	-577	-101	-44	-722
2004	-610	-93	-3	-706
2005	-589	-101	22	-668
2006	-347	-31	64	-314
2007	-182	78	42	-62
2008	-369	8	102	-259
2009	-446	-12	56	-401
2010	-462	-51	45	-468
2011	-470	-54	49	-476
2012	-374	8	98	-268
2013	-401	-39	176	-264
Average	-297	-22	52	-267

B.1.2 Confined Livestock Feeding Facility Pumping- WWUM

Memo

Adaptive Resources, Inc.

To: John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition

From: Thad Kuntz, P.G., Heath Kuntz, and Joe Reedy, G.I.

CC:

Date: 7/26/2017

Re: Robust Review: Confined Livestock Feeding Facility Pumping

Introduction

Adaptive Resources, Inc. (ARI) is completed modifications to the baseline model run of the Western Water Use Management Modeling (WWUMM) under Task 1 of the Robust Review Project Analysis (RRPA). This task includes analyzing the confined livestock feeding facility or cattle feedlot operations pumping.

Pumping data for the analysis was obtained from the North Platte Natural Resources District (NPNRD) and the South Platte Natural Resources District (SPNRD) who started collecting records for these facilities between 2009 and 2011.

Metered Pumping Records

The NPNRD pumping records include 64 cattle feedlot facilities in the overappropriated North Platte Valley and Pumpkin Creek areas. NPNRD estimated the pumping for years where failed meters, no meter was in place, or no meter reading was completed. The estimates were based on the districtwide average measured head-day pumping multiplied by either the Nebraska Department of Environmental Quality (NDEQ) permitted head, or if the feedlot is too small, an owner reported maximum head. Appendix A, Table A1 provides all NPNRD records where black numbers represent actual meter readings, and red numbers represent NPNRD estimated pumping.

The SPNRD pumping records include 5 cattle feedlot facilities. Appendix A, Table A2 provides all annual SPNRD records.

Cattle Statistics and Estimated Pumping

A method to determine pumping before meter records use the United States Department of Agriculture (USDA) National Agricultural Statistics Survey (NASS) statistics to determine the total number of cattle on feed. However, the only statistics that are available from the USDA NASS is total cattle including calves per county per year. Table 3 provides the total cattle per year for each NRD starting in 1997.

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Table 3: USDA NASS Annual Cattle Statistics Per NRD (Head including Calves)

	NPNRD	SPNRD		NPNRD	SPNRD
1997	429,688	102,000	**2006**	411,469	86,000
1998	449,393	104,000	**2007**	426,662	87,000
1999	453,637	102,000	**2008**	421,087	86,300
2000	453,637	98,000	**2009**	419,087	81,900
2001	448,637	94,000	**2010**	412,587	83,700
2002	432,419	89,000	**2011**	412,587	84,700
2003	415,200	85,000	**2012**	421,805	86,300
2004	411,931	82,000	**2013**	405,906	96,000
2005	412,444	84,000			

Estimated Pumping from Well Capacity Information

For the COHYST portion of the RRPA, The Flatwater Group estimated the number of cattle on feed based on the total pumping capacity of well(s) queried from the Nebraska Department of Natural Resources (DNR) well registration database that serves feeding facilities. In the NPNRD, there are a total 198 feedlot wells (multiple wells per feedlot). However, 68 of the 198 wells are not registered with DNR. Therefore, no pumping capacity data can be obtained from these wells, so consequently, we are not confident about providing an estimate using The Flatwater Group methodology.

Pumping Estimation Methodology

To provide the estimated consumptive use pumping for the confined livestock feeding facilities from 1997 through 2009 for NPNRD or 2010 for SPNRD, we used the reported pumping data to derive an estimated head in feedlots. The estimated head is compared to the NASS statistics to create a ratio to adjust the NASS statistics to represent the number of cattle in feedlots backward through time. The methodology was necessary as the only data available from 1997 through 2010 is the NASS total cattle.

The NPNRD pumping records from 2010 through 2013 was incomplete. To fill the incomplete records, a calculation using the NPNRD reported certification capacity and an estimated total pumping amount per head in gallons per day (GPD) was completed, as seen in the following equation.

$$Annual\ Capacity\ per\ Certification \times 7\ Gallons\ per\ Day \times 365.25\ Days$$
$$= Total\ Annual\ Pumping\ per\ Certification$$

The document titled PPRIP COHYST AREA Livestock Population Analysis, provided in an email from Jessie Winter (Strom) of Nebraska Department of Natural Resources on April 7, 2017, listed the 7 GPD per head water use estimate as an assumption. The finalized total pumping per NRD (2010 through 2013) is provided in Table 6.

Memo

Table 6: Revised Annual Total Pumping per NRD (Gallons)

	2010	2011	2012	2013
NPNRD	894,164,617	784,305,372	865,235,670	844,237,764
SPNRD		103,612,952	163,038,542	148,280,636

Note: SPNRD values were not revised, as capacity information was not available for certifications/wells that were missing data.

To estimate the number of cattle in feedlot facilities per year for each NRD, the revised annual total pumping was divided by 7 GPD per head and 365.25 days. This estimate was compared to the NASS statistics of each NRD to develop a ratio of metered pumping cattle numbers to NASS statistics, provided in Tables 7 and 8.

Table 7: Comparison of NPNRD Pumping Estimated and USDA NASS Cattle Numbers (Head)

	2010	2011	2012	2013	Average
NPNRD	349,727	306,759	338,412	330,200	331,274
NASS	412,587	412,587	421,805	405,906	413,221
Ratio	85%	74%	80%	81%	80%

Table 8: Comparison of SPNRD Pumping Estimated and USDA NASS Cattle Numbers (Head)

	2011	2012	2013	Average
SPNRD	40,525	63,768	57,996	54,096
NASS	84,700	86,300	96,000	89,000
Ratio	48%	74%	60%	61%

The historical USDA NASS data were adjusted using the average ratio for each NRD (80% for NPNRD and 61% for SPNRD). Table 9 provides the adjusted and revised pumping estimated cattle numbers.

Table 9: Adjusted Annual Cattle Numbers per NRD (Head)

	NPNRD	SPNRD		NPNRD	SPNRD
1997	344,495	61,931	**2006**	329,888	52,216
1998	360,293	63,145	**2007**	342,069	52,823
1999	363,696	61,931	**2008**	337,599	52,398
2000	363,696	59,502	**2009**	335,995	49,727
2001	359,687	57,073	**2010**	349,727	50,820
2002	346,684	54,037	**2011**	306,759	40,525
2003	332,880	51,609	**2012**	338,412	63,768
2004	330,259	49,787	**2013**	330,200	57,996
2005	330,670	51,002			

Memo

Using the adjusted annual cattle numbers per NRD the annual cattle consumptive use pumping was calculated before being distributed to the final pumping dataset. The calculated consumptive use pumping values are shown in Table 10. The consumptive use was calculated with the following equation:

$$Annual\ Total\ Cattle\ per\ NRD\ \times\ 7\ Gallons\ per\ Day\ \times\ 365.25\ Days$$
$$= Total\ Cattle\ Water\ Consumptive\ Use$$

Table 10: Adjusted Annual Cattle Water Consumptive Use Pumping per NRD (Gallons)

	NPNRD	SPNRD		NPNRD	SPNRD
1997	880,786,468	158,341,064	**2006**	843,441,836	133,503,250
1998	921,179,944	161,445,790	**2007**	874,585,179	135,055,613
1999	929,878,768	158,341,064	**2008**	863,155,713	133,968,959
2000	929,878,768	152,131,610	**2009**	859,056,055	127,138,560
2001	919,629,622	145,922,157	**2010**	894,164,617	129,932,814
2002	886,384,648	138,160,340	**2011**	784,305,372	103,612,952
2003	851,089,844	131,950,886	**2012**	865,235,670	163,038,542
2004	844,389,048	127,293,796	**2013**	844,237,764	148,280,636
2005	845,439,864	130,398,523			

A comparison of 1997 estimated CAFO pumping to each successive year was conducted to understand any variability in estimated pumping through time. This comparison is demonstrated in Table 11. Positive values indicate greater pumping in that year, and negative values indicate less pumping as compared to 1997.

Table 11: Difference Between 1997 and Successive Year's Estimated Pumping for each NRD (Acre-Feet)

	NPNRD	SPNRD		NPNRD	SPNRD
1998	124	10	**2006**	-115	-76
1999	151	0	**2007**	-19	-71
2000	151	-19	**2008**	-54	-75
2001	119	-38	**2009**	-67	-96
2002	17	-62	**2010**	41	-87
2003	-91	-81	**2011**	-296	-168
2004	-112	-95	**2012**	-48	14
2005	-108	-86	**2013**	-112	-31

A review of the difference between estimated annual (1998-2013) pumping and estimated baseline (1997) pumping revealed relatively minor changes in consumptive use historically. As these changes represent a negligible portion of pumping that occurs in the system, there may be limited value to modeling these facilities.

Memo

APPENDIX A

Memo

Table A1: Annual Livestock Metered Pumping per Certification in NPNRD (Gallons)

Certification	2008 Gallons Used	2009 Gallons Used	2010 Gallons Used	2011 Gallons Used	2012 Gallons Used	2013 Gallons Used
1008	No Meter	6,596,700	1,348,700	917,300	589,200	1,269,600
1071	755,480	1,026,560	9,720	No Meter	No Meter	No Meter
1096	9,160,400	9,807,400	5,298,060	No Meter	No Meter	No Meter
1136	No Meter	4,659,000	70,602,390	1,242,310	450	0
1156	No Meter	248,460	0	527,070	231,740	198,180
1225	No Meter	8,542,480	1,279,670	7,223,820	702,660	477,490
1332	No Meter	2,569,580	12,532,470	5,283,600	4,938,270	1,031,170
1388			Failed Meter	32,028,750	19,162,500	24,637,500
1395	Failed Meter	Failed Meter	Failed Meter	Failed Meter	Failed Meter	Failed Meter
1434	No Meter	No Meter	1,260,160	1,019,560	6,832,990	5,552,780
1497	No Meter	3,076,010	2,671,800	2,463,700	2,795,970	2,021,400
1625	No Meter	50,031,245	35,856,857	4,303,909	37,651,736	59,130,000
1793	No Meter	No Meter	92,865,200	74,584,600	166,585,800	178,234,600
1840	No Meter	No Meter	2,373,720	7,421,780	10,800,210	12,294,560
2123	No Meter	1,218,100	19,675,100	14,355,600	18,895,700	20,815,300
2176	No Meter	1,125,900	3,964,600	2,149,900	3,832,500	4,974,300
2274	No Meter	100,284,200	100,993,500	2,330,600	2,299,500	2,541,700
2275	No Meter	1,189,100	7,286,600	7,419,500	10,828,800	12,070,418
2350	No Meter	1,911,700	10,064,100	11,621,600	10,219,800	11,732,900
2412	No Meter	No Meter	60,317,180	21,530,406	20,452,393	35,865,003
2491	No Meter	55,400	25,533,900	16,920,800	19,427,200	36,796,000
2501	No Meter	7,696,285	18,214,740	15,424,368	16,648,660	4,221,469
2516	No Meter	No Meter	185,100	178,100	104,900	345,100
2523	No Meter	No Meter	2,174,500	2,435,600	2,784,200	4,146,200
2634	No Meter	5,166,200	20,047,400	14,062,600	34,618,400	42,740,100
2667	No Meter	No Meter	13,225,200	21,503,000	5,330,000	3,963,400
2771	No Meter	No Meter	812,420	786,270	704,540	697,170
2826	No Meter	2,389,280	12,029,765	46,898,955	No Meter	No Meter
2837	No Meter	91,270	548,100	437,530	459,810	1,166,890
2874	No Meter	132,945,984	Not Read	6,405,750	3,832,500	4,927,500
2894	No Meter	86,590	808,880	8,030,470	8,171,410	7,832,780
2895	No Meter	43,380	67,410	86,140	30,180	13,580
2959	No Meter	12,066,390	17,587,520	49,211,900	Failed Meter	Failed Meter

Memo

Table A1 Continued: Annual Livestock Metered Pumping per Certification in NPNRD (Gallons)

Certification	2008 Gallons Used	2009 Gallons Used	2010 Gallons Used	2011 Gallons Used	2012 Gallons Used	2013 Gallons Used
2960	No Meter	594,700	1,137,900	1,528,800	1,022,000	1,314,000
2981	No Meter	683,330	321,320	229,100	299,230	569,200
3005	No Meter	16,145,660	40,744,251	66,213,291	88,467,732	62,415,000
3008	No Meter	1,784,018	1,673,881	2,877,564	2,059,685	6,570,000
3009	No Meter	152,171	218,318	879,464	457,816	8,212,500
3010	No Meter	2,772,966	1,925,436	5,484,999	11,879,115	3,285,000
3011	No Meter	2,334,375	1,631,847	1,951,504	No Meter	No Meter
3030	No Meter	21,021,106	15,450,735	21,071,504	7,125,406	9,523,595
3041	No Meter	1,299,070	2,203,140	5,614,360	5,290,390	2,428,340
3056	No Meter	No Meter	8,519,900	18,333,300	18,648,500	44,897,200
3073	No Meter	210,070	537,350	358,200	577,860	580,570
3079	No Meter	7,994,708	4,983,628	10,601,519	16,299,053	21,270,380
3095	No Meter	746,600	114,100	174,200	381,400	489,500
3101	No Meter	12,698,492	45,141,027	62,024,222	52,846,680	51,214,214
3171	No Meter	1,438,293	Not Read	19,217,250	19,162,500	14,782,500
3174	No Meter	92,500	4,864,560	5,414,950	3,176,430	3,089,480
3189	No Meter	No Meter	13,500	43,010	134,830	44,150
3190	No Meter	No Meter	8,778,900	8,477,300	8,900,000	7,850,500
3217	No Meter	19,267,700	21,457,700	16,926,000	15,394,700	18,645,800
3231	No Meter	No Meter	No Meter	21,447,274	35,131,415	1,504,740
3243	No Meter	211,950	412,190	271,330	177,540	229,360
3252	No Meter	2,064,600	3,467,600	3,625,700	2,373,900	2,477,900
3300	No Meter	1,093,780	1,998,040	1,341,520	1,611,510	1,459,130
3346	No Meter	3,031,800	5,197,900	6,365,000	8,838,700	7,223,000
3361	No Meter	1,439,162	2,375,975	219,947	42,965,774	12,661,910
3393	No Meter	No Meter	1,122,800	2,405,600	2,760,100	2,694,200
3401	No Meter	No Meter	9,594,600	158,300	5,122,200	5,287,000
3437	No Meter	91,000	2,017,500	1,680,300	806,400	860,800
3629	No Meter	4,195,890	5,059,632	5,957,913	5,529,831	4,069,977
3647	No Meter	No Meter	452,900	11,360,400	12,212,200	9,400,800
3648	No Meter	No Meter	30,162,224	87,748,200	29,957,470	1,162,901
Total Annual Pumping	9,915,880	454,191,157	761,213,617	768,807,509	808,542,388	785,910,739

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Table A2: Annual Livestock Metered Pumping per Meter in SPNRD (Gallons)

Meter	2010 Gallons Used	2011 Gallons Used	2012 Gallons Used	2013 Gallons Used
7080962	13,273,015	70,163,960	93,967,407	85,278,035
6982485	10,393,700	12,720,000	13,644,800	13,644,800
6982484	4,863,100	12,675,700	14,168,800	12,286,200
8110115		7,075,592	37,113,935	33,841,300
8110738		977,700	4,143,600	3,230,300
Total Annual Pumping	28,529,815	103,612,952	163,038,542	148,280,636

B.2 Evaluation of Sandpits and Small Reservoirs

2019

Upper Platte River Basin Consumptive Use Change from New Reservoirs and New or Expanded Sandpit Lakes: 2005 to 2010

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6/7/2019

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Background

As part of its commitment to the Platte River Recovery Implementation Program (Program), the Nebraska Department of Natural Resources (NeDNR) estimates the cumulative impacts of new surface water-related activities within the State's portion of the Program area (**Figure 1**). NeDNR monitors most new surface water-related activities in Nebraska through the surface water permitting process; however, small waterbodies like sandpits used in gravel and sand mining, and reservoirs smaller than 15 acre-feet (af), do not require surface water permits. Thus, the Department has conducted the following study to estimate the cumulative impacts of new surface water activities attributed to these small waterbodies.

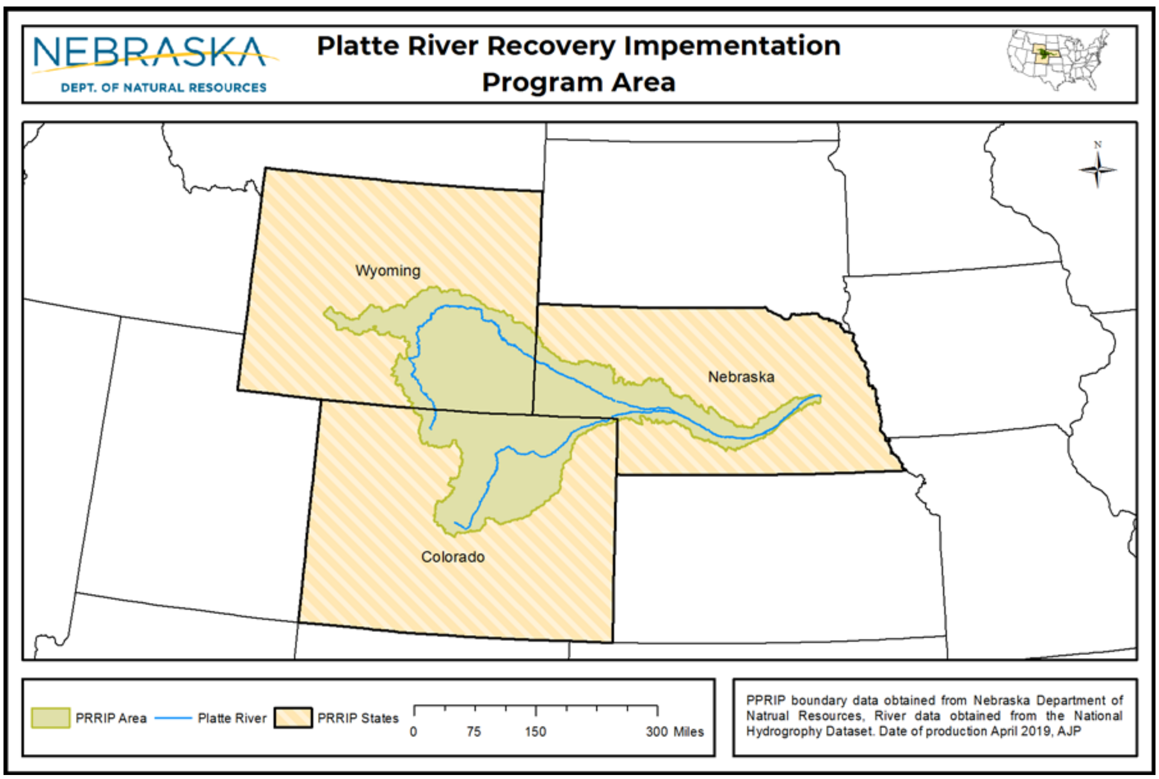

Figure 1. The Platte River Recovery Implementation Program in Nebraska, Wyoming, and Colorado.

History and Description of the Platte River Recovery Implementation Program

On July 1, 1997, the states of Nebraska, Colorado, and Wyoming, and the US Department of the Interior, entered into a cooperative agreement to address the needs of four target species: the endangered whooping crane, interior least tern, and pallid sturgeon, and the threatened piping plover, along the central Platte River Basin. As part of that agreement, a Governance Committee formed of representatives from the three basin states, the US Bureau of Reclamation, the US Fish and Wildlife Service (USFWS), water users, and environmental groups, developed the foundation for the Program. In early 2006, the Governance Committee presented a final program document, which provided direction regarding the management of land and water resources for the benefit of the four target species. The Program officially commenced on January 1, 2007 after the Secretary of the Interior and the governors of Nebraska, Wyoming, and Colorado signed the final Program agreement.

The Program brings together the involved states, federal agencies, water users, and environmental groups to work collaboratively to improve and maintain the associated habitats for the designated, target species, in 13-year increments. The first increment spanned the years 2007 to 2019 and utilized an adaptive management approach supported by data and scientific research. This has allowed the Program to test hypotheses and adjust goals and targets accordingly, throughout the first increment.

The three main elements of the Program are to:

- Increase stream flows in the central Platte River during relevant time periods
- Enhance, restore, and protect habitat lands for the target bird species
- Accommodate certain new water-related activities.

The Program's Adaptive Management Plan, Land Plan, and Water Plan support these elements. The Adaptive Management Plan sets the framework for how Program management uses the best available science and data. The Land Plan details the Program's long-term objective to acquire land interests for habitat restoration. The Water Plan is the road map developed to meet water goals of the Program.

The USFWS has established stream flow targets for the Platte River based on the habitat needs of the Program's target species. As part of the Program's Water Plan, each of the collaborating states and the federal government developed "Depletion Plans" that describe mitigation, offsets, or prevention of any new stream depletions that started after July 1, 1997, and with regard to target flows. Nebraska's New Depletion Plan covers the surface water basin within the state of Nebraska and above Columbus, NE, and will hereinto be referred to as the "study area" (**Figure 2**).

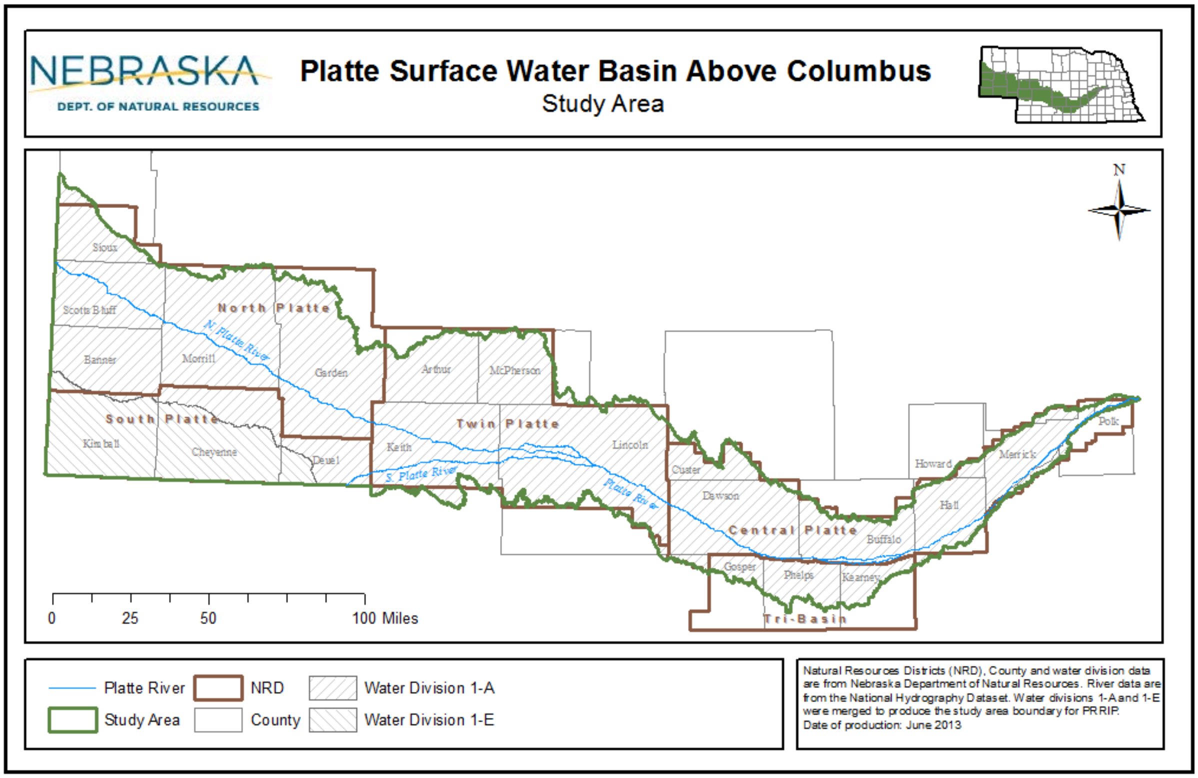

Figure 2. The study area consists of the Nebraska portion of the Program area, which is the Platte River Basin above Columbus, Nebraska.

In compliance with the Nebraska New Depletions Plan, the State must consider potential effects of new or expanded small water bodies on target flows. The purpose of this study is to assess the cumulative impact of new or expanded sandpit lakes and new, small reservoirs on target flows. This study has two overarching objectives:

1. Identify new or expanded sandpits and other small water bodies that do not require permits from NeDNR that occurred between the years 2005 and 2010.
2. Utilize the Natural Resources Conservation Service (NRCS) Evapotranspiration (ET) calculator to determine what water consumption impact, if any, could be attributed to the new or expanded small, unpermitted waterbodies.

2005 and 2010 waterbody inventories and change detection

Introduction

This section describes the work performed to create an inventory of 2005 and 2010 waterbodies. It details the procedures used to compare inventories in order to identify potential new reservoirs and new or expanded sandpit lakes, and then determine whether the new or expanded waterbodies had permits, plans or mitigation already in place. NRD staff provided local expertise to review and further refine the dataset. A geospatial layer of new reservoirs and new or expanded sandpits was finalized for subsequent consumptive use analyses.

Creation of the baseline (2005) waterbody inventory

In 2006, the NeDNR created a 2005 waterbody inventory to establish baseline conditions for this study. This GIS-based inventory was created using manual identification, digitization, and classification of waterbodies through interpretation of 2005 Farm Service Agency (FSA) orthophotography. NeDNR classified the waterbodies as follows:

- **Reservoirs** - Water bodies with a visible dam structure or those in upland drainages that had a linear edge perpendicular to an incised drain
- **Sandpits** - Human-made water bodies located within the flood plain of a river or stream
- **Lakes** - Irregular shaped water bodies in floodplains or upland depressions (not in a natural drain)
- **Miscellaneous** - Visible water bodies that do not fall into the other categories, including treatment plants, animal waste pits, etc.

The 2005 baseline inventory identified roughly 11,500 waterbodies (**Figure 3**). The methodology used in the creation of the 2005 baseline inventory was relatively labor intensive and required approximately 1,200 staff hours to complete.

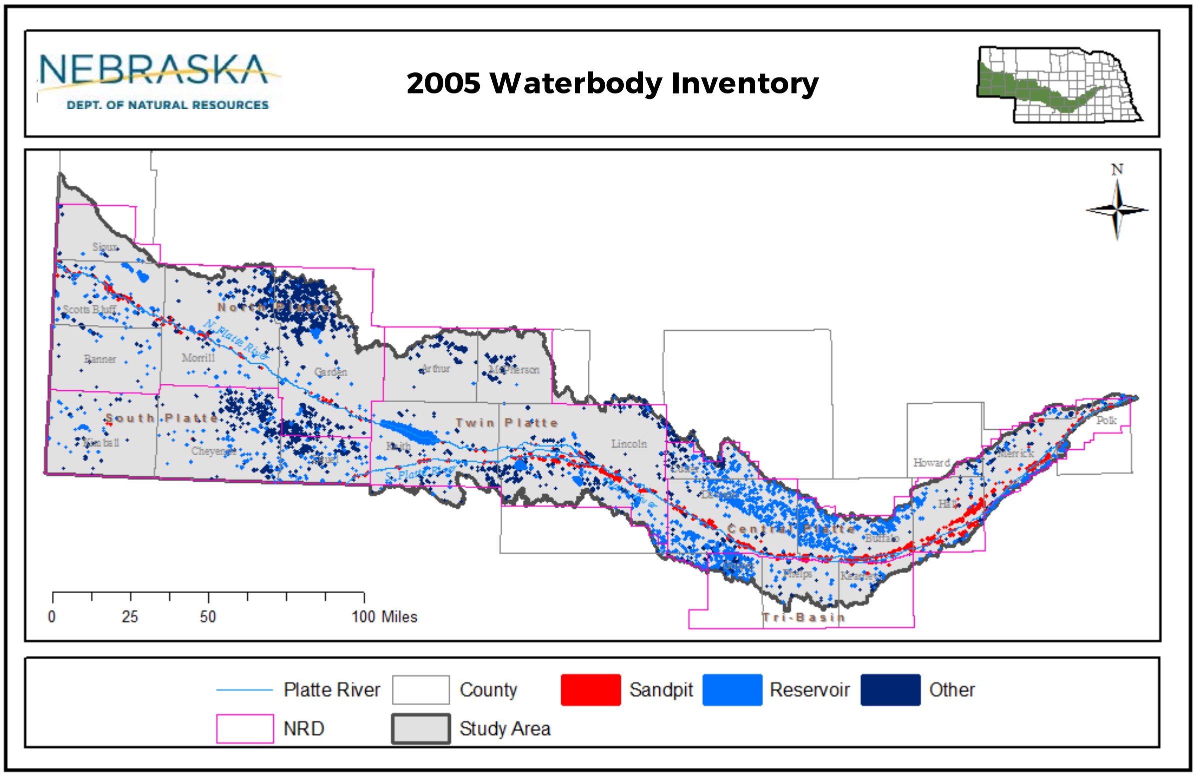

Figure 3. The 2005 waterbody inventory used as a baseline for the change analysis.

Creation of the 2010 waterbody inventory

Preparation

In 2011, and inventory of 2010 waterbodies was created using a semi-automated classification methodology. An initial comparison of 2005 and 2010 aerial imagery showed a considerable increase in waterbodies in 2010 due to it being a much wetter year than 2005. **Figure 4** shows FSA imagery of the same area in 2005 and 2010, and provides a visual example of the significant increase in surface water from 2005 to 2010. It was estimated that the 2010 inventory would take approximately 4,000 hours to complete if the same manual methods employed in 2005 were used. As such, a semi-automated classification was employed as a first-cut to identify waterbodies. This classification utilized 2010 FSA National Agriculture Imagery Program (NAIP) one-meter resolution aerial imagery to discriminate waterbodies based on the unique spectral reflectance characteristics of open water.

Figure 4. Aerial imagery showing differences in surface water between a drier year (2005, left) and a wetter year (2010, right)

County-level FSA images were combined using ERDAS IMAGINE software to create a single image of all counties within the study area. The Nebraska Sandhills region in the northern portion of the study area was removed because waterbodies in this region were assumed to be natural features. Because dataset size was an issue, the 2010 imagery mosaic was resampled to a resolution of 5-meters as visual inspection showed that 5-meter pixels were appropriate for the waterbody discrimination. This step greatly reduced the file size of the dataset.

Classification

To conduct the classification, values from the near infrared (NIR) band of FSA imagery were evaluated visually to determine the difference in NIR reflectance between vegetation and waterbodies. Reflectance values represent the amount of light at specific wavelengths (in this case near infrared) reflected back to the sensor by specific land cover type. Vegetation and waterbodies have uniquely different reflectance in the NIR band, which ranges from 0.7 to 1.2 micrometers in the electromagnetic spectrum. Vegetation has high reflectance in the NIR band, while open water has high absorption in this region. As a result, NIR reflectance values for vegetation are generally high while values for open water tend to be low.

A pixel-based threshold (0-128) was determined through visual inspection and used to isolate potential pixels that represented waterbodies. This threshold represented the left "tail" of the bell-shaped histogram of all land cover types and associated pixel values from 0-255 in the study area (**Figure 5**). Groups of contiguous pixels that would theoretically constitute a waterbody were then isolated and converted to polygons (shapes). Polygons smaller than 1-acre were removed as visual examination revealed that these were generally artifacts or ephemeral water bodies.

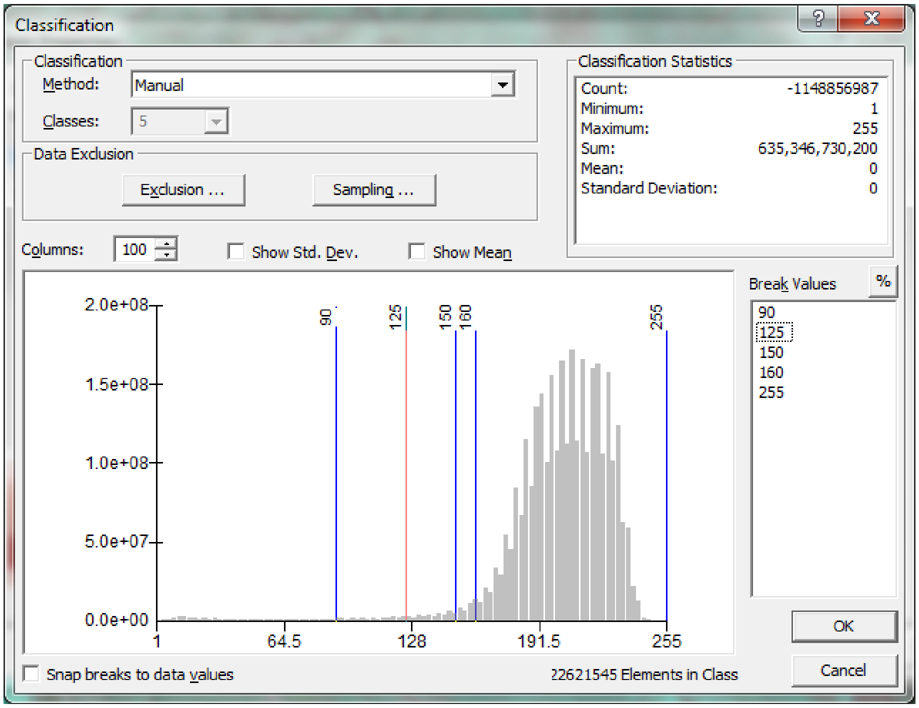

Figure 5. Histogram showing all near-infrared pixel values in the study area. Values of 0 to 128 were selected as a first-cut to isolate waterbodies.

An example of 2010 FSA imagery during the classification process is shown in **Figure 6**. In this image, waterbodies appear as black or very dark grey, indicating high levels of near-infrared absorption. Vegetation, on the other hand, appears light gray or white due to high reflectance in the near-infrared band. Of note, there were some issues with the classification of FSA imagery for this project. For example, high levels of suspended solids in some reservoirs produced confusion in the classification due to higher reflectance of soils and other particles within the waterbodies. Additionally, very wet soils, shadows of clouds, trains, and other features also had high absorption in the near-infrared spectrum and produced unwanted features (i.e. “artifacts”).

There were also inconsistencies between aerial imagery tiles across the study area because FSA imagery is captured at different times and from different angles. Satellite-based imagery, which is acquired at the same time and from the same vantage point, generally produces more consistent classification results, but at the expense of resolution. Landsat imagery was considered for this study, but it was determined that the 30-meter resolution was not sufficient to discriminate small waterbodies. As such, the FSA approach was used to retain a fine spatial resolution (5 m after resampling); however, this approach did require substantial manual editing.

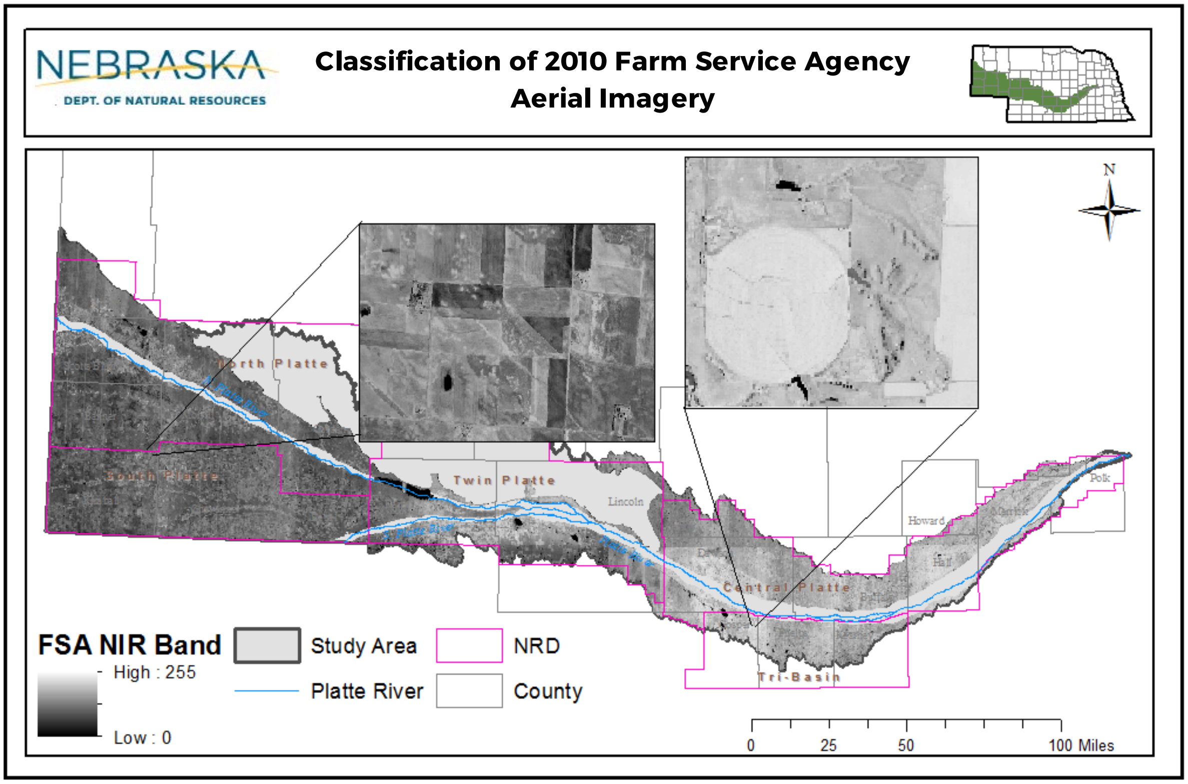

Figure 6. FSA aerial imagery near-infrared (NIR) band classification. Waterbodies appear dark grey or black due to strong absorption in the NIR band.

<u>Manual editing of first-cut waterbody features</u>

The initial image classification for the 2010 small waterbody inventory required substantial manual work. For this process, NeDNR staff members methodically reviewed the entire study area, using 1-meter FSA imagery as a backdrop to inspect and edit roughly 20,000 features. All scanning, editing, and digitizing occurred at a minimum scale of 1:10,000. GIS editing tools were employed to remove artifacts (e.g. shadows, wet soils) produced from the classification process. Likewise, editing tools were used to digitize “missing” waterbodies; e.g., waterbodies that were misclassified typically due to a high sediment content. The automated classification process performed the best for sandpit waterbodies, which are generally clear and have low levels of suspended materials, resulting in high absorption of the NIR wavelengths. Staff also categorized the waterbodies as they reviewed the dataset (discussed further in next section). **Figure 7** shows the results of the 2010 waterbody inventory, which included classification, manual editing, and categorization of the features.

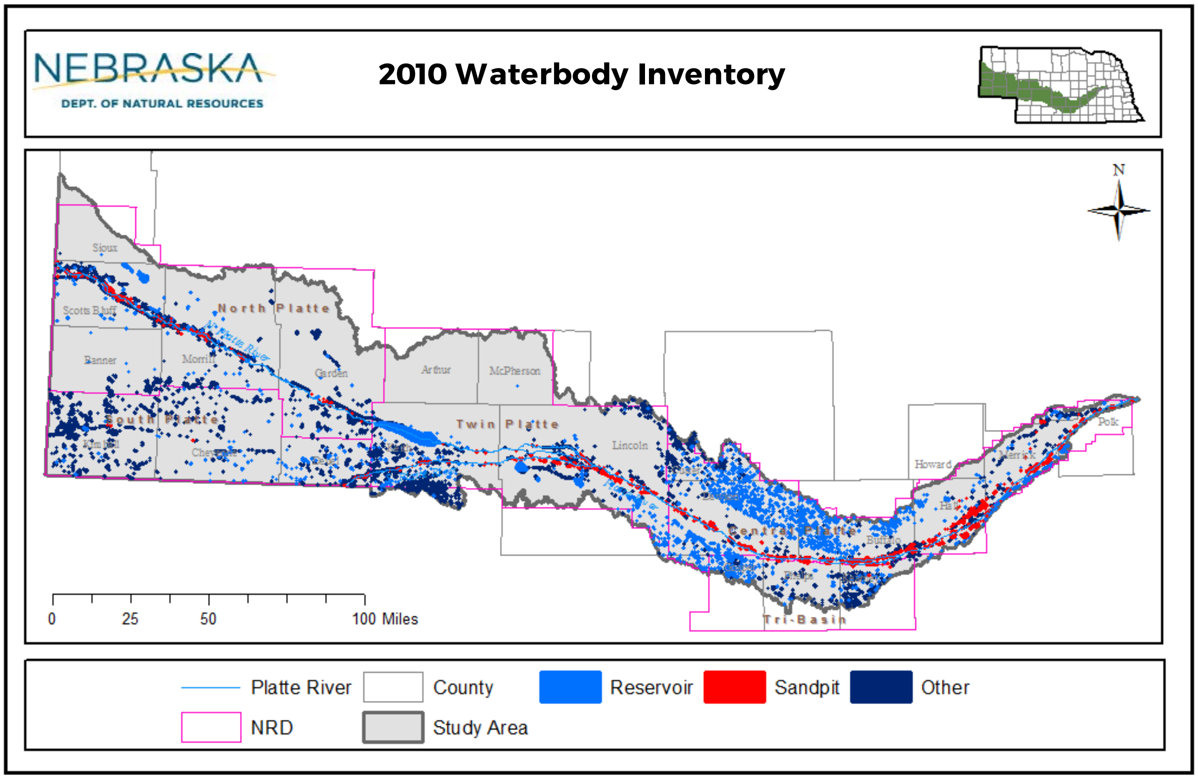

Figure 7. Classification and editing results of 2010 waterbodies.

Categorization of Waterbodies

During the editing process, staff categorized waterbodies based on 18 surface water classification as shown in **Table 1**. The process of categorizing these waterbodies took into consideration the shape, size, and association with other identifiable features, such as proximity to the Platte River, farmlands, or towns and cities. For example, staff categorized waterbodies that intersected streams and/or had visible embankments as “reservoirs”; and features within the Platte River valley that had the characteristic sandpit shape as “sandpits”. Other feature classifications used to categorize waterbodies in this step included reuse pits, natural lakes, and water treatment facilities.

It should be noted that features in the 2005 waterbody inventory had been classified using four broad categories (lake, reservoir, sandpit, and miscellaneous), and therefore needed to be recategorized to match the 2010 waterbody categories. To accomplish this, staff kept the 2005 dataset in the GIS mapping project view and compared it with the 2010 inventory throughout manual editing. Waterbodies from both years were reviewed and edited as necessary to ensure features were lining up and that categories were consistent between the years.

After digitizing and initial categorization, staff merged the waterbody categories into six general categories: Active Sandpit, Inactive Sandpit, Reservoir, Feedlot, Industrial/Municipal, and Other (**Table 1**). Features classified as Feedlots, Industrial/Municipal, or Other were removed (but preserved as a supplemental dataset) from the database because the Department has other mechanisms in place to account for depletions due to these uses. Features categorized as Reservoirs or Sandpits (Active and Inactive) were retained for both the 2005 and 2010 datasets.

Table 1. Waterbody categories used in the 2010 inventory.

Waterbody Category	Generalized Category
Feedlot	Feedlot
Industrial	Industrial/Municipal
Municipal	
Golf Course	Reservoir
Reservoir	
Reservoir-off NHD and Large	
Urban Recreation	
Sandpit-active	Sandpit Active
Sandpit-inactive	Sandpit Inactive
Natural Lake	Other
Natural Other	
Natural Reservoir	
Other	
Question	
Re-use pond/Natural Field Depression	
Re-use pond-engineered with banks	
Water Backup from Road	
Watering Hole	

Waterbody Change Analysis: 2005 to 2010

Identification of potential new reservoirs and new or expanded sandpits

The 2010 waterbody inventory revealed 1,578 features classified as reservoirs and 1,005 features classified as sandpits. Staff overlaid the features onto the 2005 inventory layer to identify non-overlapping features, which would indicate potential new reservoirs, or new or expanded sandpits. From this overlay process, it was determined that there were 573 potentially new reservoirs and 185 sandpits with significant area change in 2010. In all, the first-cut change analysis dataset identified 758 potentially new or expanded waterbodies with a cumulative surface area of 3,723 acres (**Figure 8**).

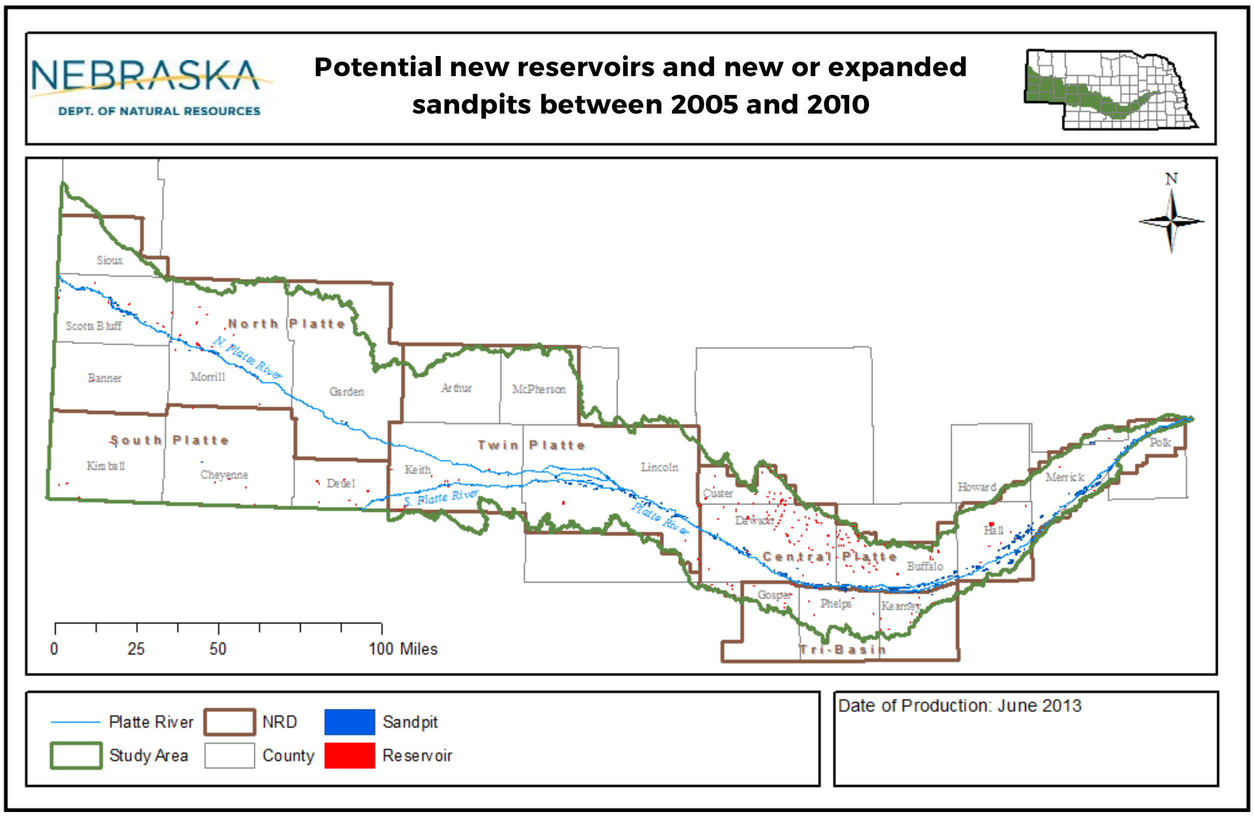

Figure 8. Map of potential new reservoirs or new or expanded sandpits between 2005 and 2010.

Evaluation of potentially changed waterbodies

Next, staff conducted additional research to determine if any of the potentially new or expanded waterbodies were actually new, and if so, if these had existing permits, plans, offsets, and/or mitigation. For reservoirs, staff utilized aerial imagery to evaluate whether potentially new reservoirs had embankments built between 2005 and 2010. Examples of two reservoirs with new embankments are shown in **Figure 9**. If there was a pre-existing embankment, the reservoir was removed from further analyses as it had had the capability to store water in 2005, even if there was no water present in that year. As a result, only 11 out of the 573 reservoirs identified in the first-cut analysis were determined to be "new" by the presence of a new embankment.

Figure 9. Aerial imagery from 2005 (left) and 2010 (right) shows enbankments and surface water from two new reservoirs, detected as a part of this study.

Reservoirs were then evaluated for existing permits to store water or for plans on file with NeDNR's dam safely section. It was determined that two of the reservoirs had either a surface water permit or a dam safety plan on file with NeDNR, and were therefore removed from the dataset. At this point, there were nine new reservoirs retained for further analysis regarding consumptive use.

The 185 sandpit lakes that had been determined to have significant area change from 2005 to 2010 were also reviewed. NeDNR records were reviewed to check if there were any pre-existing offsets in place. The sandpit lakes were visually inspected using aerial imagery to determine whether they had actually changed and what, if any, mitigation measures were already in place. **Figure 10** shows an example of mitigation that occurred for a sandpit lake between 2005 and 2010. Although the sandpit had increased in size due to expanded mining, there had been some filling in of the open water (mitigation) along one end of the sandpit. These areas of expansion and mitigation were separated geospatially and would be evaluated separately in the subsequent consumptive use analyses. Of the 185 sandpits with significant area change, 98 were determined to be sandpits with actual change. Of those, four had some level of mitigation in place.

Figure 10. An example of a sandpit lake from 2005 (top left), 2010 (top right), with both mitigation and expansion change (bottom left).

<u>Review of waterbody features by NRD staff</u>

As a final check, the geospatial dataset of new reservoirs and new or expanded sandpits was separated by NRD and sent to each respective NRD for review. An example of one feature identified as "changed" that had not actually changed, per NRD staff evaluation, is shown in **Figure 11**. In this instance, a sandpit lake had been identified as expanded, but NRD staff with local knowledge indicated that the enlarged shape was due to high stream flows that spilled into the lake. As such, this feature was removed from the "changed waterbody" database.

Figure 11. Example of a sandpit lake with a size increase that was not due to mining expansion, as identified by NRD staff.

<u>Synopsis of Procedure and Final Dataset for Changed Small Waterbodies</u>

A map displaying the final dataset of new reservoirs and new or expanded sandpit lakes for the entirety of the study area is shown in **Figure 12**. In all, 9 new reservoirs and 94 new or expanded sandpit lakes were identified within the PRRIP study area. The vast majority of these lie along the North Platte, South Platte, or Platte Rivers, with a few new reservoirs in or near South Platte NRD. The process of identifying these 103 total features was extensive and involved several steps. A synopsis of this change analysis and the number/area of features identified in each step is shown in **Table 2.**

In summary, the change analysis process started with a classification that yielded roughly 20,000 features for 2010, of which, many were artifacts with a reflectance similar to water. Staff members systematically analyzed these features and identified 2,500 reservoir or sandpit lake features. The analysis was then conducted by first overlaying the 2005 and 2010 waterbody inventories, which identified roughly 750 features as "potentially changed" from 2005. These features were verified through: 1) visual inspection of aerial imagery, 2) comparison to permits, plans and offset documentation on file with NeDNR, and 3) NRD staff review. In total, 103 features were retained for subsequent consumptive use analysis discussed in the next sections.

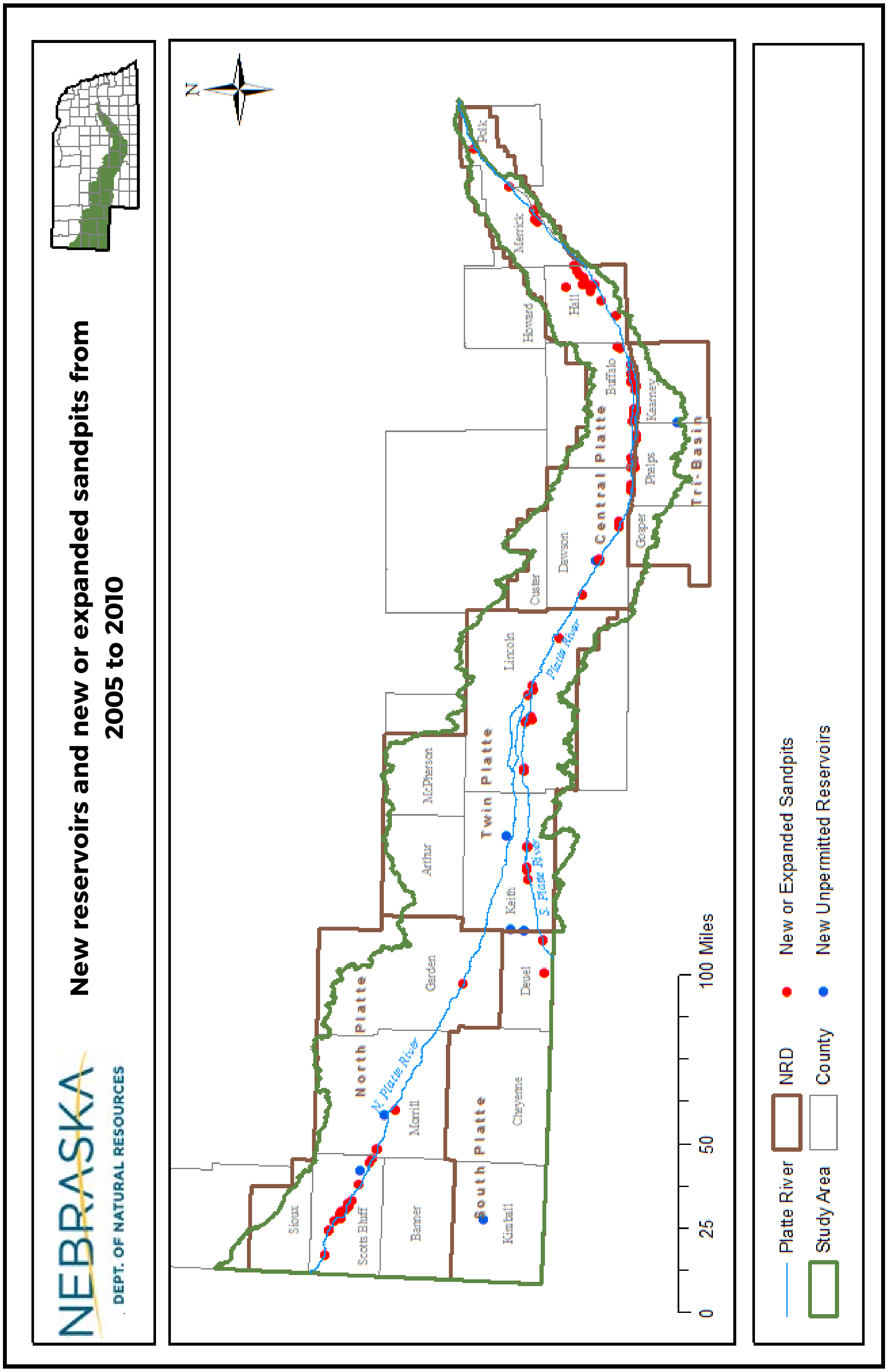

Figure 12. New reservoirs and new or expanded sandpits results between 2005 and 2010.

Table 2. Synopsis of change analyses and features/area in each step.

Change Analysis: Reservoirs		
Procedure	**Features**	**Area (acres)**
Reservoirs classified from 2010 imagery	1,578	45,507
Reservoirs with no overlap with 2005 inventory	573	1,521
Reservoirs with new embankments between 2005 and 2010	11	405
New reservoirs with permits between 2005 and 2010	(2)	386
New unpermitted reservoirs between 2005 and 2010	9	19
Change Analysis: Sandpit Lakes		
Procedure	**Features**	**Area (acres)**
Sandpits classified from 2010 imagery	1,005	8,050
Sandpits with area change from 2005	185	2,202
New/expanded sandpits (no offsets and post-visual inspection)	98	736
New sandpits with mitigation	(4)	8
New/expanded sandpits between 2005 and 2010	94	728

Consumptive Use (ET) Calculations for New or Expanded Waterbodies

The next step in evaluating the effects of changes in small waterbodies was to determine differences in ET due to the change from the prior land cover to open water. This was accomplished using the NRCS Consumptive Use Calculator (Calculator). The Calculator is Excel-based and has been used by the NRCS and USFWS for consumptive use calculations for biological opinions.

The Calculator uses reference crop ET that is translated to land use consumptive use using monthly coefficients that are hard-coded into the calculator. Estimation of consumptive use using this Calculator requires several inputs, including surface area, soil texture, land cover, and location within one of eight pre-defined climate zones.

Creation of Input Layers for the NRCS Consumptive Use Calculator

The following sections describe the process of creating the necessary inputs for the Calculator. Here, GIS data pertaining to soils, land cover, and climate zones were assembled and adapted for Calculator inputs.

<u>Soil texture</u>

The Calculator requires soil texture (relative percentage of sand, silt, and clay in soils) data for the location(s) where consumptive use calculations will be applied. For this study, GIS data to describe soil texture were acquired from the 1:250,000 State Soil Geographic Database (STATSGO). This widely used US dataset for soils has extensive data about soil characteristics, not only on the land surface, but also within the soil profile. For this study, information about soil textures at the surface was extracted for Calculator inputs. The entire study area was processed and then specific areas with new waterbodies were extracted for Calculator use. The STATSGO soil texture classifications were more refined than the Calculator pre-defined classes, so the STATSGO classes were reclassified for use as inputs for the Calculator. **Table 3** shows the reclassification scheme used to adapt STATGSO data for use in the Calculator, and **Figure 4** shows the spatial distribution of the soil texture (post-reclassification) for the entirety of the study area.

Table 3. STATSGO soil textures reclassification to adapt texture classes to the NRCS Consumptive Use Calculator.

STATSGO Soil Texture	NRCS Calculator Soil Texture
Fine Sand	Sand
Fine Sandy Loam	Sandy Loam
Sandy Loam	
Very Fine Sandy Loam	
Loamy Fine Sand	Loamy Sand
Loamy Sand	
Loamy Very Fine Sand	
Loam	Silt Loam
Silt Loam	

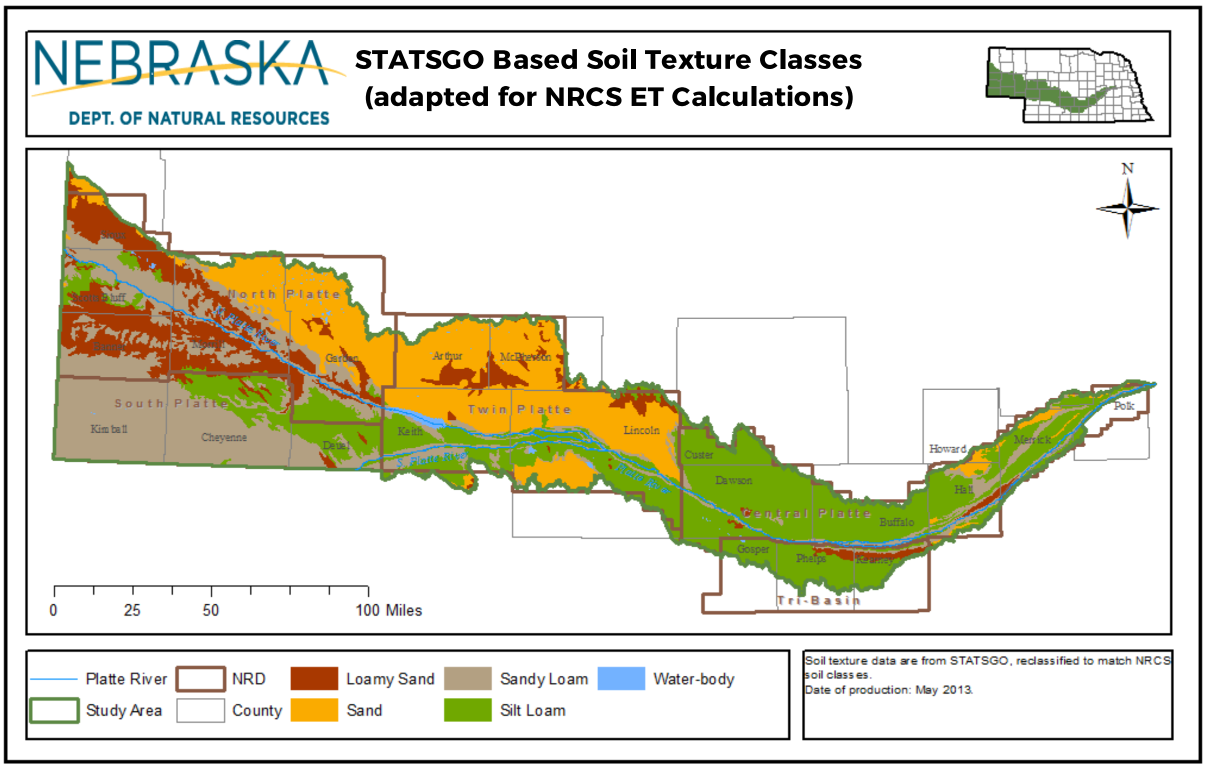

Figure 13. Spatial distribution of soil texture classes used to define soils at specific waterbody locations for consumptive use calculations.

<u>Land cover</u>

The Calculator provides 46 different land cover coefficients, including many vegetation types, bare soil, and open-water surfaces. Two statewide GIS data sources were used to determine land cover classes for use in the Calculator. The first GIS dataset that was used was the Center for Advanced Land Management Information Technologies (CALMIT) 2005 Land Use-Land Cover dataset, which is a 30-meter spatial scale raster dataset with 25 land cover classes that focus on agricultural crop types (**Figure 14**). The land use portion of CALMIT's 2005 dataset is also in vector format and provides information about irrigated vs. dryland agricultural areas. The CALMIT land cover/land use categories were reclassified to adapt to the Calculator categories as shown in **Table 4**.

The Calculator provided more options for grassland categories than did the CALMIT dataset, which was more focused on agricultural categories. As such, data from the 1993 UNL Conservation and Survey Division native vegetation map were utilized for areas where the CALMIT land cover class was either 'Range, Pasture, Grass' or 'Summer Fallow' (**Figure 14**). The native vegetation types were reclassified to correspond with the Calculator grassland options as shown in **Table 5**.

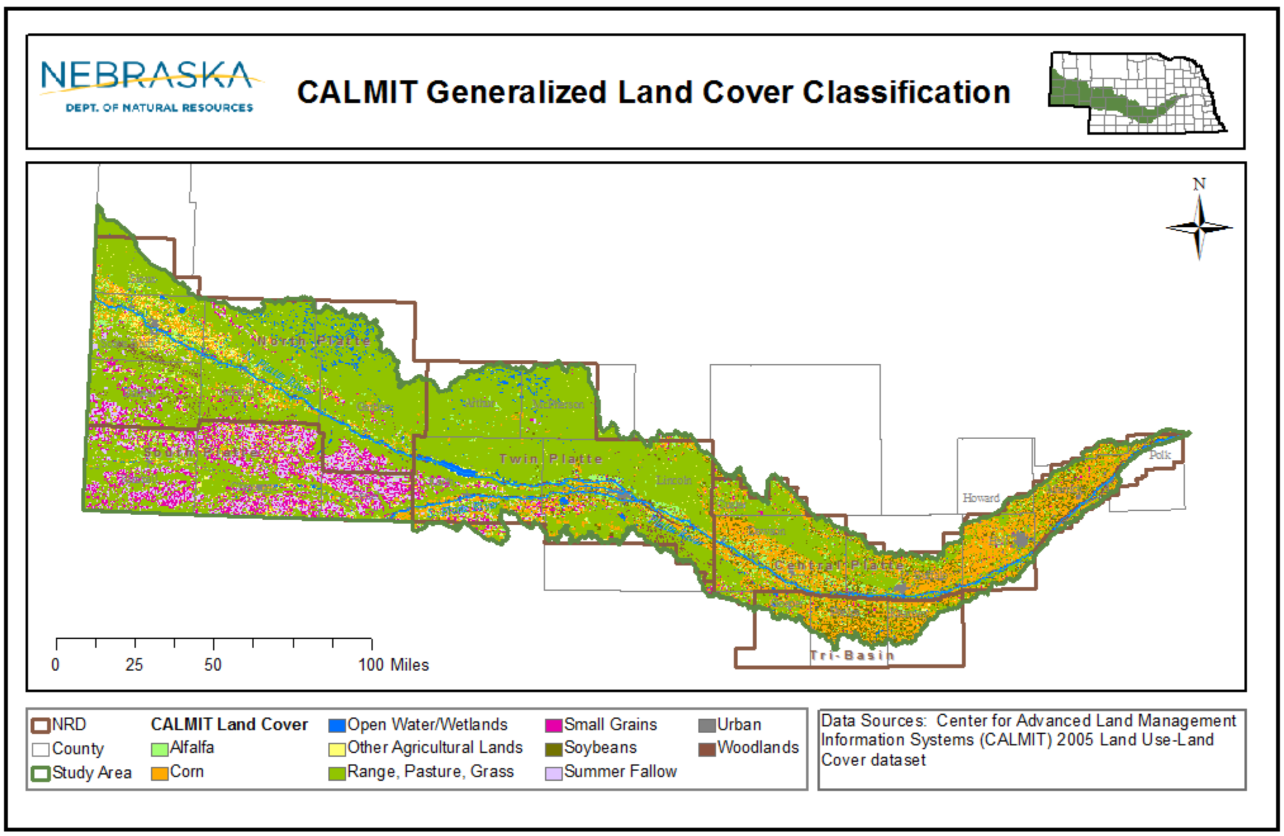

Figure 14. CALMIT land cover/land use dataset with generalized categories.

Table 4. Reclassification scheme for CALMIT land use-land cover adaption to Calculator categories.

CALMIT Land Use/Cover Class	NRCS ET Calculator Land Use/Cover Class
Dryland Alfalfa	Dryland Alfalfa
Irrigated Alfalfa	Irrigated Alfalfa
Barren	Bare Soil
Other Agricultural Land	
Roads	
Urban Land	
Dryland Corn	Dryland Corn
Irrigated Corn	Irrigated Corn
Irrigated Sugar Beets	
Irrigated Potatoes	
Range, Pasture, Grass	Refer to Table 4 for a breakdown of this land cover type
Summer Fallow	
Dryland Small Grains	Dryland Millet
Irrigated Small Grains	Irrigated Millet
Dryland Sorghum (Milo, Sudan)	Dryland Sorghum
Irrigated Sorghum (Milo, Sudan)	Irrigated Sorghum
Dryland Dry Edible Beans	Dryland Soybeans
Dryland Soybeans	
Irrigated Dry Edible Beans	Irrigated Soybeans
Irrigated Soybeans	
Dryland Sunflower	Dryland Sunflower
Irrigated Sunflower	Irrigated Sunflower
Open Water	Water (Deep)
	Water (Shallow)
Wetlands	Wet Tall Grasses
Riparian Forest and Woodlands	Trees (Average of Cottonwood and Willow)

Table 5. Reclassification scheme for UNL-CSD native vegetation adaption to Calculator categories.

UNL CSD Native Vegetation Types	NRCS Land Cover Class
Gravelly Mixed-grass Prairie	Grass Warm Short/ Grass Cool Short
Loess Mixed-grass Prairie	Grass Warm Tall
Lowland Tall grass Prairie	Grass Warm Tall/ Grass Cool Tall
Mosaic of Mixed-grass/Short grass Prairie	Grass Warm Short
Ponderosa Pine Forests and Savannas	Conifers
Riparian Deciduous Forests	Trees (Cottonwood and Willow)
Salt Marsh and Flats	Wetlands
Sand Hills Borders Mixed-grass Prairie	Grass Warm Mid
Sand Hills Mixed-grass Prairie	Grass Warm Mid
Upland Tall grass Prairie	Grass Cool Tall

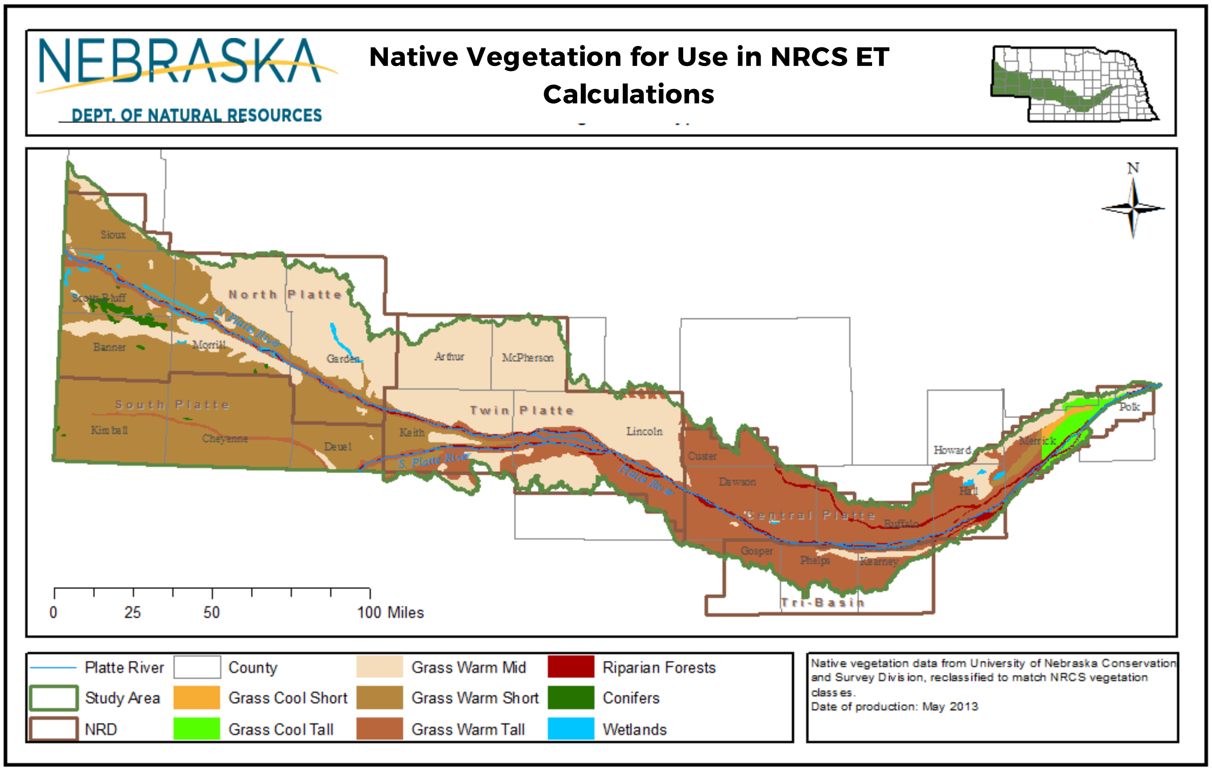

Figure 15. Spatial distribution of native vegetation in the study area; these were used to sub-divide grassland depicted in the 2005 CALMIT land cover dataset.

<u>Climate zones</u>

The NRCS consumptive use calculator documentation designates eight unique climate zones for the Platte River Basin, to be used for ET calculations (**Figure 16**). These areas have unique combinations of vegetation phenology, seasonal evaporation, and other climatic conditions.

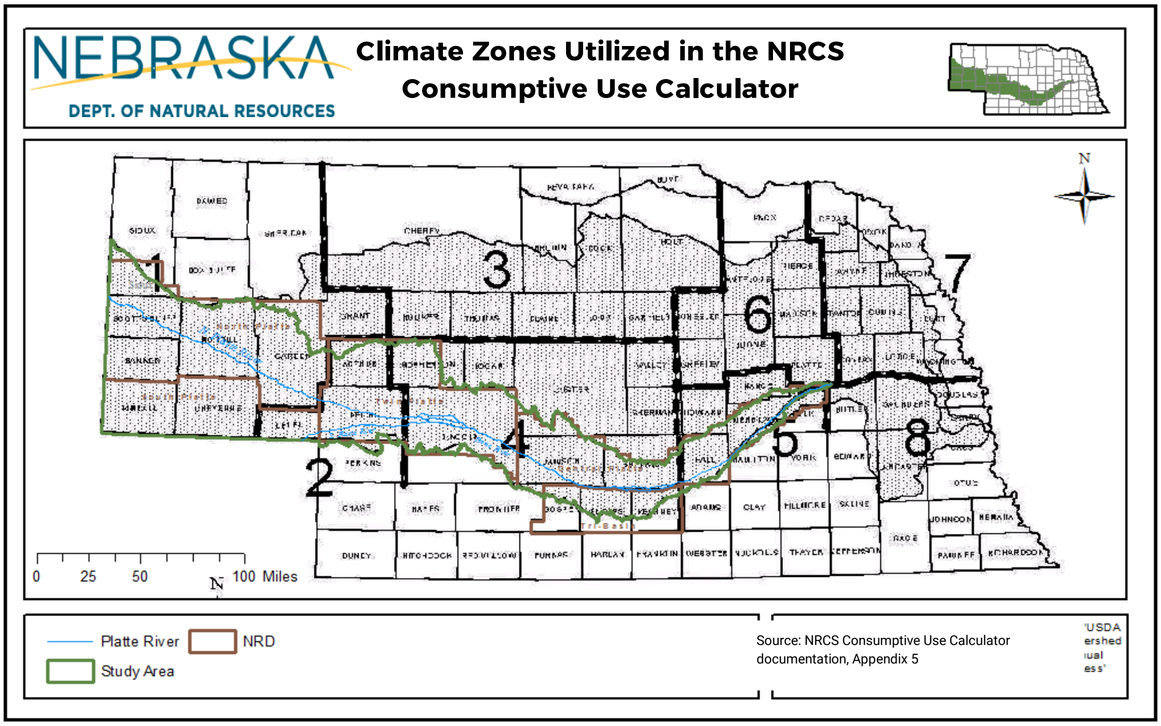

Figure 16. NRCS climate zones used in calculations of consumptive use for the study area.

Implementation of NRCS Calculator

The NRCS calculator was used to estimate ET for the 103 waterbodies identified as new or expanded. A before (2005) and after (2010) calculation was run for each of the waterbodies, and the difference was used to determine change in ET. In using the Calculator to estimate ET, the following assumptions and decisions were made:

- Cottonwoods and willows were used to represent riparian trees.
- Wet tall grasses were used to represent wetlands.
- Daily irrigation was set to run from May to September for irrigated crops.
- Small reservoirs represented shallow water (less than 1 meter averaged over the water area)
- Sandpits represented deep water (over 1 meter when averaged over the water area)
- Mitigated areas of expanded sandpits were modeled as follows: ET for deep water (2005 condition) to ET for sand (2010 condition).

Results

This section presents the results of analyses on the changes to ET due to new or expanded small waterbodies with no surface water permits, dam safety plans, or offsets by the Department between 2005 and 2010. The first set of results discusses the effects on ET from reservoirs, and the second set of results discusses the effects on ET from sandpits.

Consumptive Use Change for New Reservoirs

There were nine "unregulated" reservoirs, accounting for 18 acres in total, constructed within the study area between 2005 and 2010 **(Figure 17)**. The term "unregulated" refers to new reservoirs that had no surface water permits, dam safety plans, or offsets in place upon construction and through 2010.

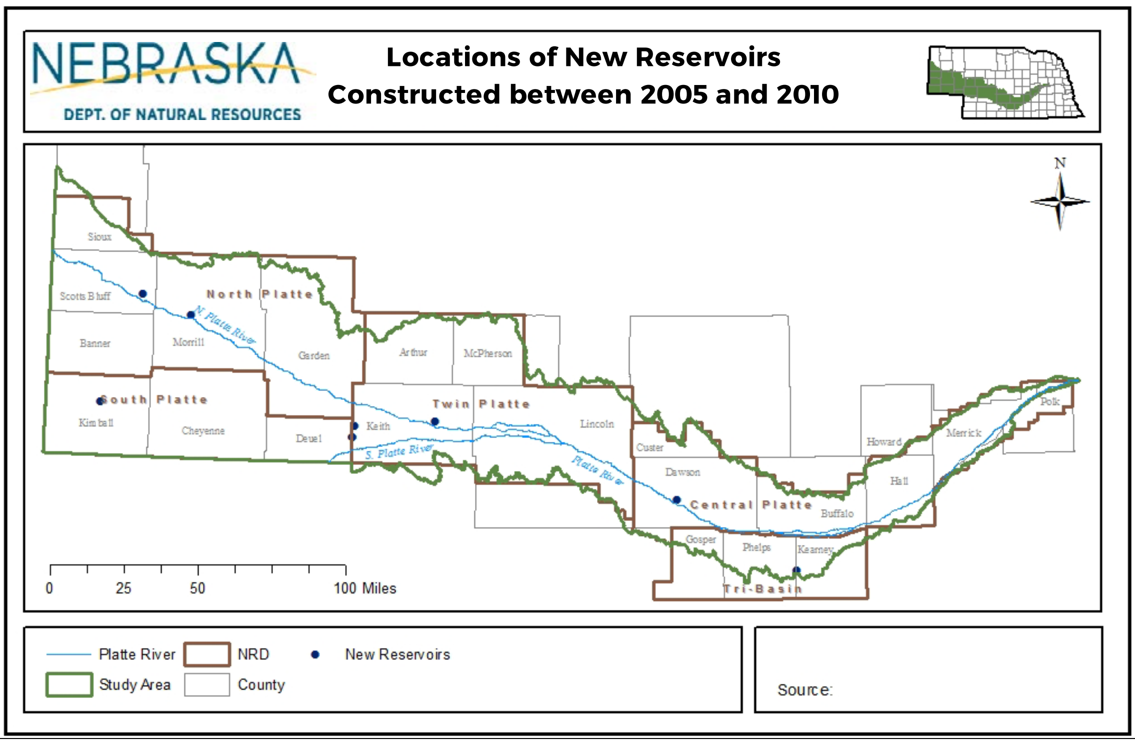

Figure 17. Locations of new reservoirs for consumptive use analysis.

The distribution of land cover/land use types that existed in the locations of the reservoirs prior to conversion to open water is provided in **Table 6**. Combined grassland (modeled as native types) comprised about 63 percent, irrigated crops comprised 26 percent, and dryland crops comprised 11 percent of the area prior to conversion to open water. The associated ET with these land cover/land use types resulted in 7 af for dryland crops; 9 af for grassland; and 16 af for irrigated crops, with 10 af of the total irrigated crops associated with irrigated alfalfa. In all, about 32 af of consumptive use per year was occurring in these areas prior to reservoir development. Nearly half of the consumptive use was associated with irrigated crops, 30 percent associated with grassland, and the remainder (22 percent) associated with dryland crops. Please see Appendix A to access more detailed information about how specific land cover/land use types are modeled in the Calculator with regard to ET.

Table 6. Land cover/land use types and associated ET of new reservoir areas prior to conversion to open water.

Prior Land Cover and Associated Evapotranspiration (ET) for New Reservoir Areas				
Prior land cover (2005)	**Acres**	**ET (af)**	**Acres (%)**	**ET (%)**
Dryland Alfalfa	1	4	6	12
Dryland Millet	1	3	7	10
Grass Warm Mid	1	2	5	7
Grass Warm Short	10	4	50	14
Grass Warm Tall	1	3	6	9
Irrigated Alfalfa	3	10	15	30
Irrigated Corn	1	6	11	18
Total	**18**	**32**	**100**	**100**

The modeled ET for the combined prior land cover/land use against the post-land cover (open, shallow water) is shown in **Figure 18**. Monthly change in consumptive use that occurred from conversion of the initial land cover/land use to a reservoir (modeled as open, shallow water) is presented in **Figure 21**. When summed, there was a total increase of 18.4 af of ET due to the conversion of 19 acres to shallow, open water. A little less than half (9 af) of that ET increase occurred in the non-peak season months of March, April, October, and November (winter months are not included in the Calculator due to minimal ET). The highest monthly differences were in April, May, September, and October, where agricultural vegetation would be in initial growth stages, or senescence and harvest. The lowest differences were at the height of the growing season where more ET would be occurring in agricultural areas, which as modeled, would be close to the amount of evaporation occurring on open, shallow water.

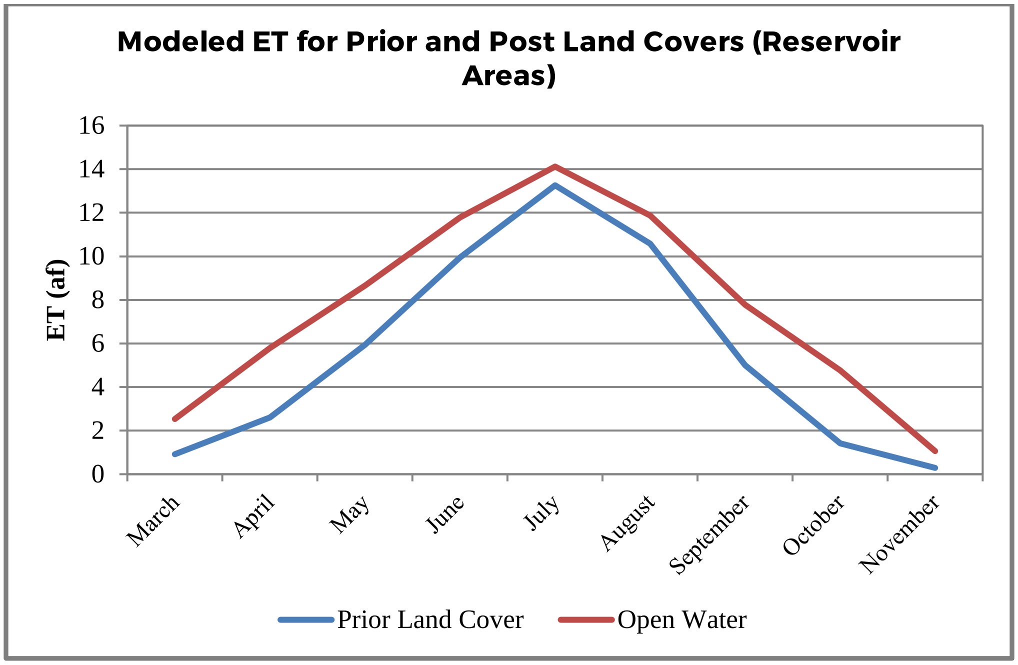

Figure 18. Modeled ET for prior and post land covers in new reservoir areas.

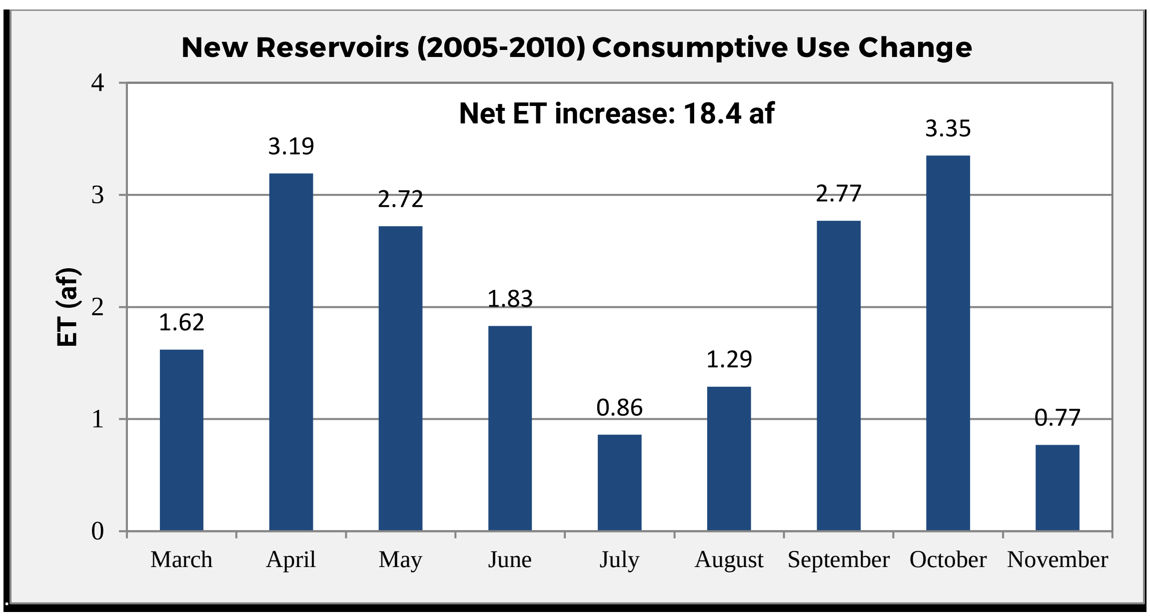

Figure 19. Change in ET due to land coversion to reservoirs, expressed in monthly values from March to November.

Consumptive Use Change for New or Expanded Sandpits

Between 2005 and 2010, 94 sandpits were either built or expanded within study area. The total area of land that the new and expanded sandpits encompassed was 734 acres. The total area of active sandpits that reduced in size between 2005 and 2010 was 145 acres. This resulted in 879 sandpit-related acres that underwent a change in land cover type between 2005 and 2010. The locations of new or expanded sandpits are shown in **Figure 20**.

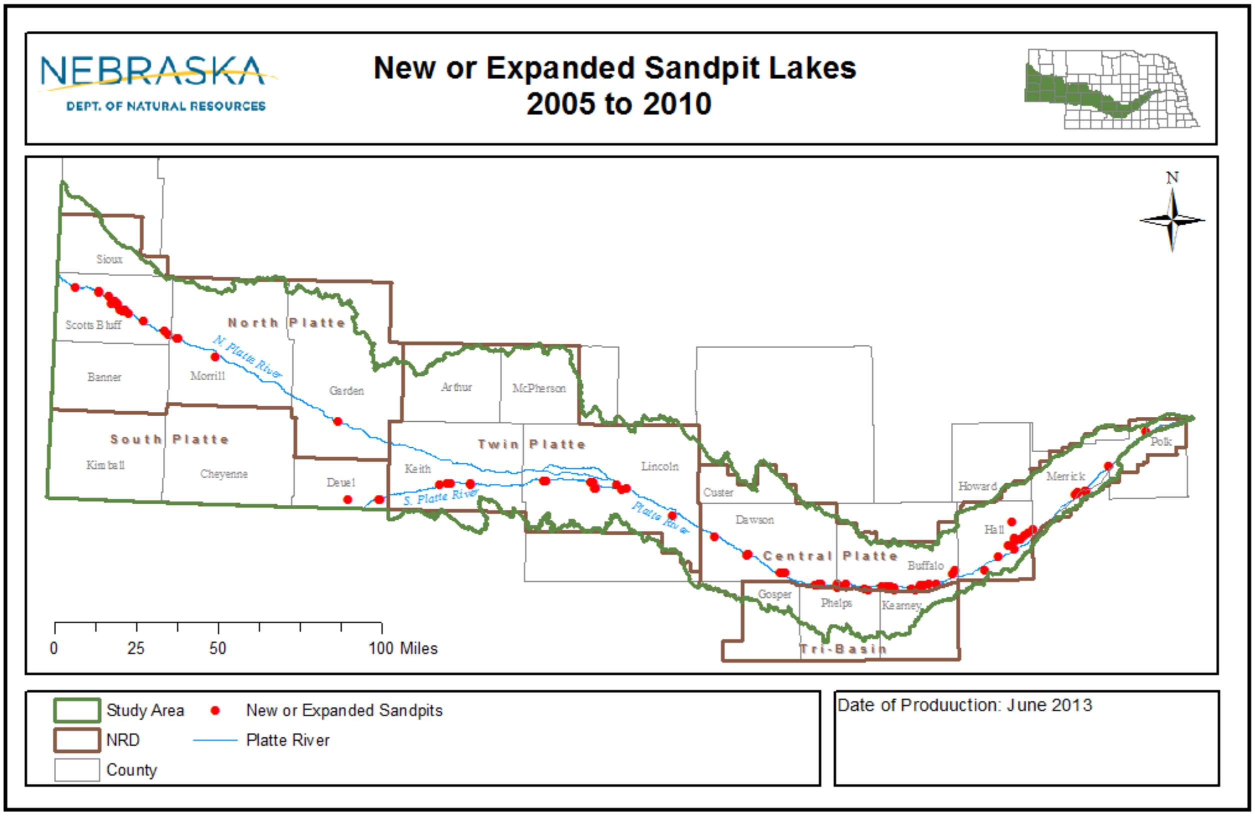

Figure 20. Locations of new or expanded sandpits within the Platte Surface Water Basin above Columbus.

The distribution of land cover/land use type that existed in the locations of new or expanded sandpits prior to conversion to open water is provided in **Table 7**. Most (85 percent) of the pre-sandpit lake area was comprised of riparian forests and woodlands, wetlands, and grasslands, as would be expected in areas close to the Platte River. About 15 percent of the land cover/land use, most of which was irrigated (13 percent), was devoted to agriculture prior to sandpit development. As discussed earlier, some new or expanded sandpits also had mitigation in certain areas, which totaled 145 acres across the study area. These areas were modeled as a land cover change from deep, open water to sand. Please refer to Appendix A for more information about Calculator ET values for specific land cover/land use.

Table 7. Total acres of generalized land cover and the percent contribution of each group to the total number of sandpit acres within the study are. All figures have been rounded to the nearest whole number.

Land Cover Groups to Prior New or Expanded Sandpits in the Platte SW Basin above Columbus		
Prior Land Cover Groups (2005)	**Acres**	**Acres (%)**
New/Expanded Sandpits		
Dryland Crops	18	2
Irrigated Crops	93	13
Grasslands	167	23
Riparian Forest and Woodlands	275	37
Wetlands	181	25
Sub-total (new or expanded)	734	84
Reduced Sandpit Areas		
Open Water to Sand	145	16
Total New/Expanded and Reduced Acres	**879**	**100**

A graphical comparison of the monthly ET associated with active sandpits in 2005 and 2010 (all prior and post-land cover groups were combined) is shown in **Figure 21**. Note that the prior land cover ET is much higher during the peak growing season compared to ET for the sandpit lakes. This is related to higher heat storage capacities for deep water, compared to heat storage capacities for shallow water. Solar energy is stored in the deep water and does not evaporate as readily as in shallow water. The NRCS Consumptive Use calculator modeling parameters reflect this concept, and the vegetation opposed to deep water is modeled as having higher ET for the sandpit lake areas.

Monthly change in consumptive use that occurred from conversion of the initial vegetation to a sandpit lake (or vice versa for mitigated areas) is presented in **Figure 22**. When summed, there was a total decrease of 698 af of ET due to the combined conversion of 784 acres to deep, open water (expanded or new areas), and 145 acres from sand to deep, open water (mitigated areas). The majority of the calculated ET differences occurred in the hottest summer months (June, July, and August), when sandpit lakes had less evaporation than the previous land cover due to the storage of solar energy (opposed to evaporation) in the deep, open water. Conversely, more evaporation occurred with the open, deep water than ET that occurred in the previous land cover (vegetation) for the months of March, April, October, and November.

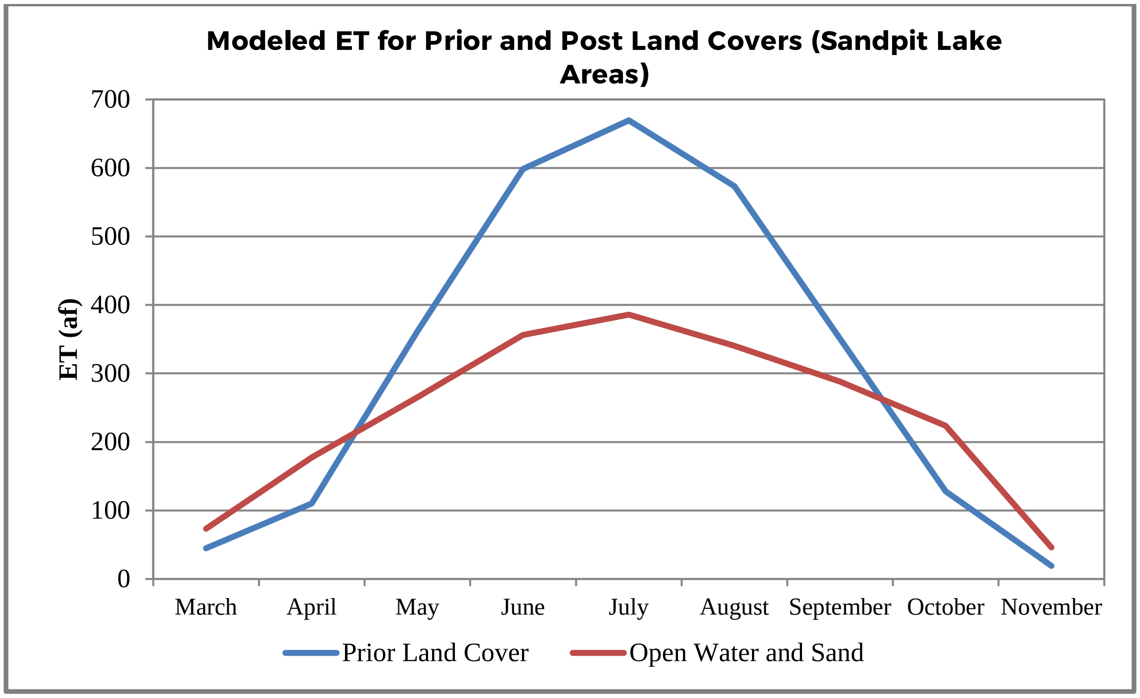

Figure 21. Modeled ET for prior and post land covers in new or expanded, or mitigated sandpit lake areas.

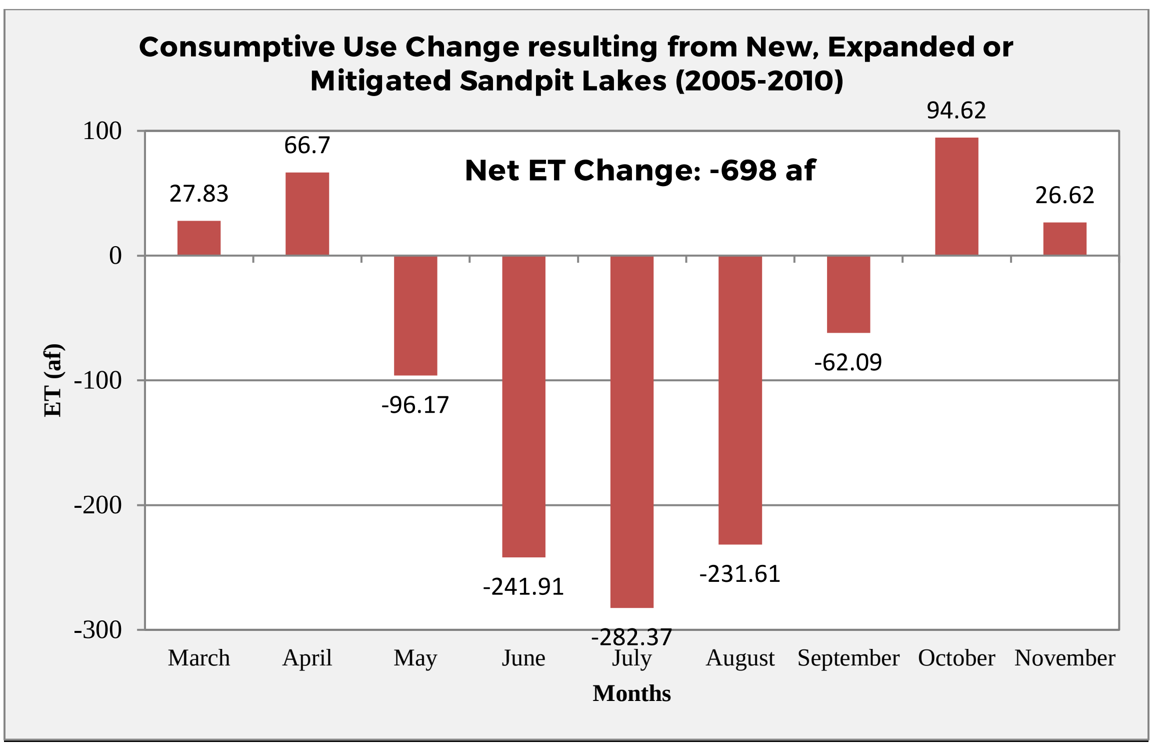

Figure 22. Change in ET due to land coversion associated with sandpit lake construction or mitigation, expressed in monthly values from March to November.

Combined Results

When combining the results of land area change to reservoirs and sandpit lakes together, the overall ET decreased by 678 af. **Figure 23** shows the total ET monthly change from new, expanded, or mitigated sandpit lakes and new reservoirs. The ET change from various sandpit lake construction dwarfs the ET change from new reservoirs in the graph; but more than 700 acres are associated with changes due to sandpit lakes, opposed to only 18 acres associated with new reservoir areas. The total ET change appears to be most affected by the conversion of vegetation to deep open water, as the deep, open water of sandpit lakes stores solar energy in the summer months that would otherwise be evaporated.

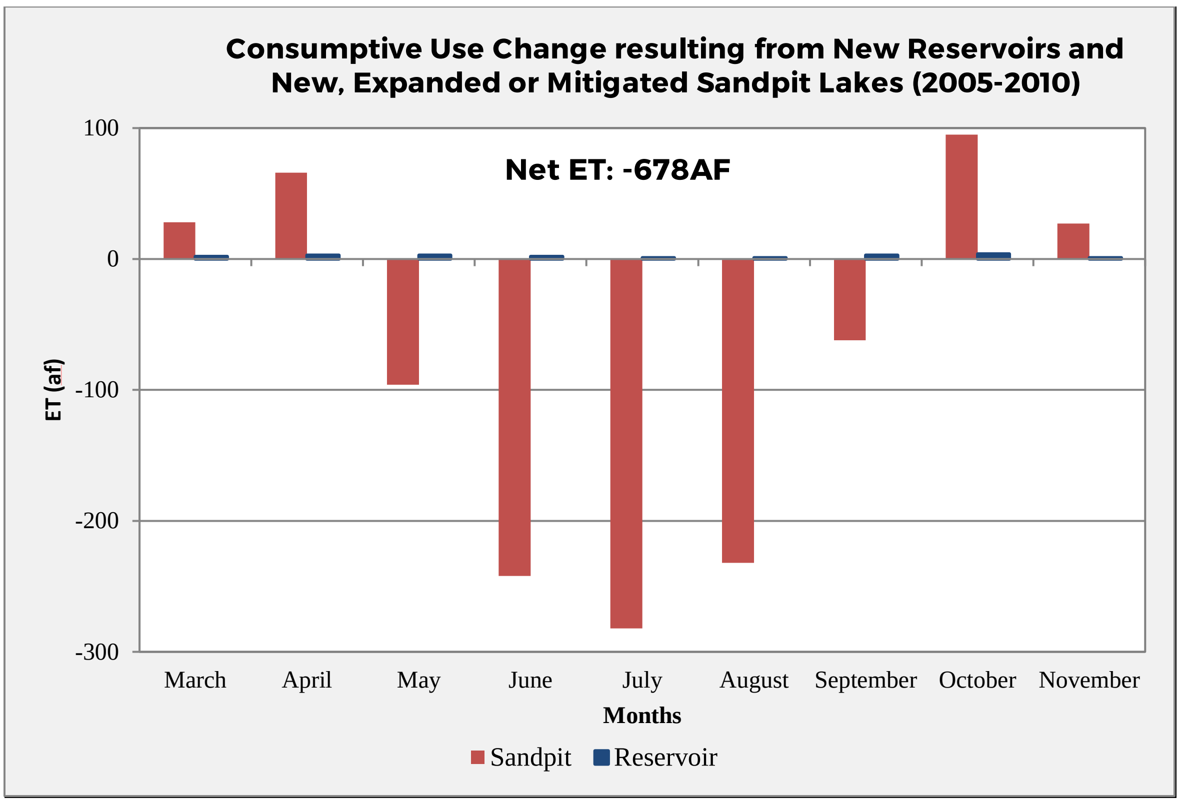

Figure 23. Overall change in ET by month, for conversion of land to new reservoirs and new or expanded sandpit lakes.

Summary

- A large effort was undertaken to create inventories of water bodies in 2005 and 2010 for the Platte River Basin above Columbus, Nebraska. An extensive amount of manual work was involved, and took an estimated 2,500 hours of NeDNR staff time to conduct.
- The extent of water bodies was affected greatly by the different precipitation amounts for each year (2010 was a wet year, so more water features were apparent on the aerial imagery).
- The inventories were compared to determine changes in water bodies that occurred between 2005 and 2010.
- The results of the inventory comparison were distilled by removing water bodies that did not have certain, apparent physical features (e.g. construction of new dams); had permits, plans, or offsets in place; and were determined by local expertise to not have actual change. What began as an analysis of thousands of features was reduced to just over 100 features that would be included in consumptive use change analysis.
- A total of 95 new or expanded sandpits and 9 new reservoirs were used for land cover/land use ET change analysis. The NRCS Consumptive Use Calculator was used to determine ET for the prior land cover/land use and for the post-land cover/land use (shallow or deep open water). Sandpit lakes with mitigation in place were also modeled to account for deep, open water that had been converted to sand.
- In all, the modeled results showed that there was an annual decrease in ET of 678 af due to new reservoirs and new, expanded or mitigated sandpit lakes, over the previous land cover/land use. These results were largely affected by the much higher acreage in sandpit lakes compared to new reservoirs and the modeled deep, open water, which stores solar energy in hot summer months, whereas vegetation in the same location would have a higher ET during these months as modeled.

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STATSGO (State Soil Geographic) Database. <https://dnr.nebraska.gov/data/soils-data>.

University of Nebraska Lincoln - Conservation and Survey Division - Native Vegetation Dataset. <http://snr.unl.edu/data/geographygis/land.aspx>.

USDA - Natural Resources Conservation Service. Consumptive Use Calculator - Evapo-transpiration Calculations for Cover Types in a Non-stressed Environment. <https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/water-planning/upper-platte/platte-river-recovery-implementation-program/nrcs.pdf>.

APPENDIX A.

NRCS Consumptive Use Calculator ET values for specific land covers

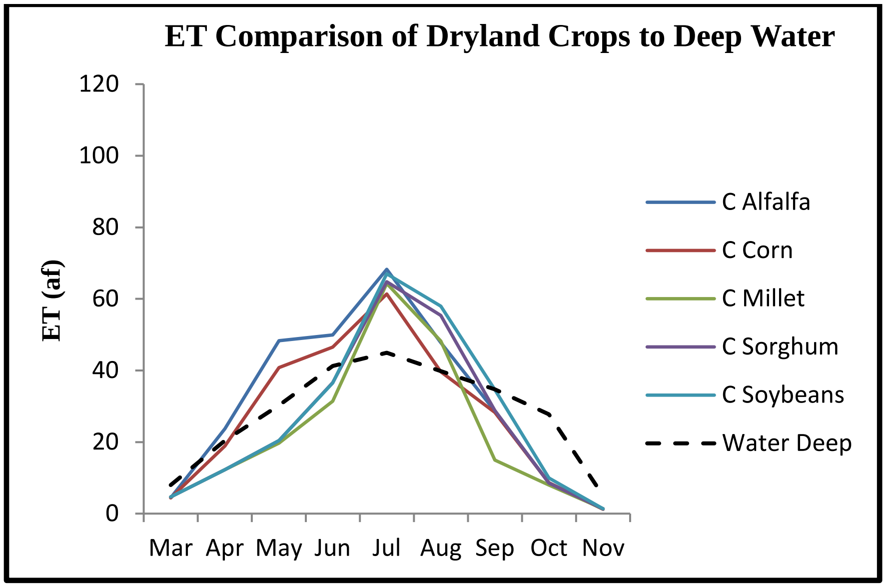


Figure B-1. The ET pattern of dryland crops per 100 acres of each dryland crop type within the study area.

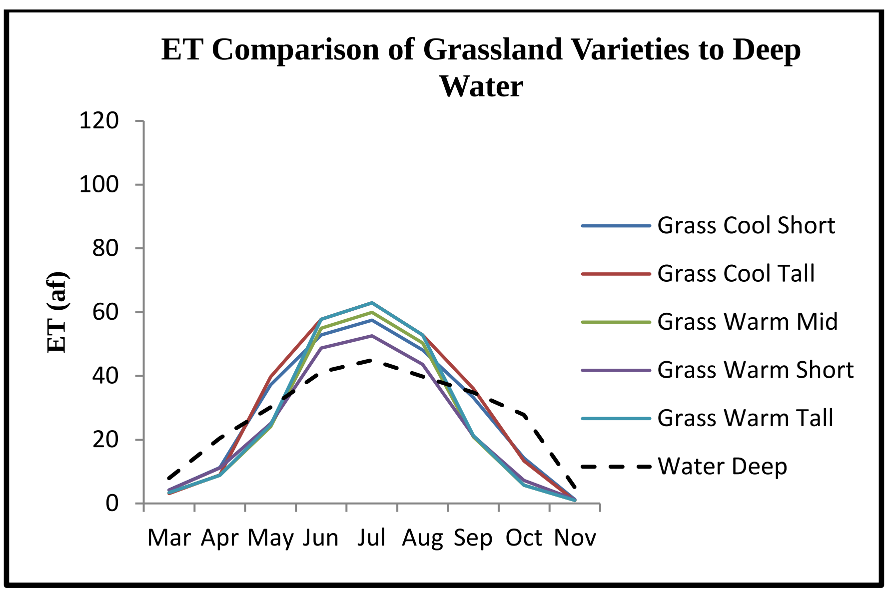


Figure B-2. The ET pattern of grasslands per 100 acres of grassland type in the study area.

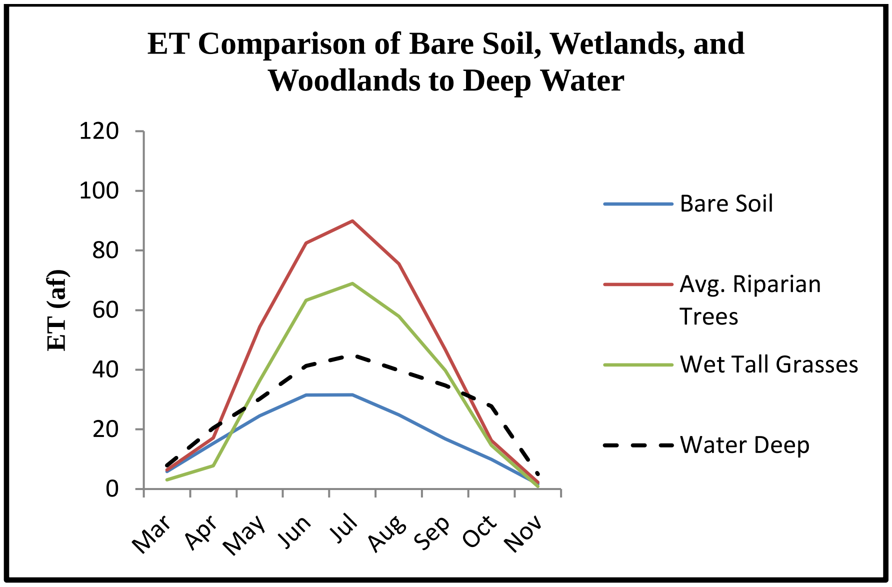


Figure B-3. The ET pattern of bare soil, wetlands, and woodlands per 100 acres of each land cover type in the study area.

2005-2010 Consumptive Use of Small Man-made Water Bodies in the Platte Surface Water Basin above Columbus

PRRIP Water Advisory Committee Meeting-May 6, 2014

Amy Zoller, MS
Integrated Water Management Analyst
Nebraska Department of Natural Resources

Nebraska
Department of Natural Resources

Introduction

Nebraska New Depletion Plan (NNDP) for the Platte River Recovery Implementation Program (PRRIP)

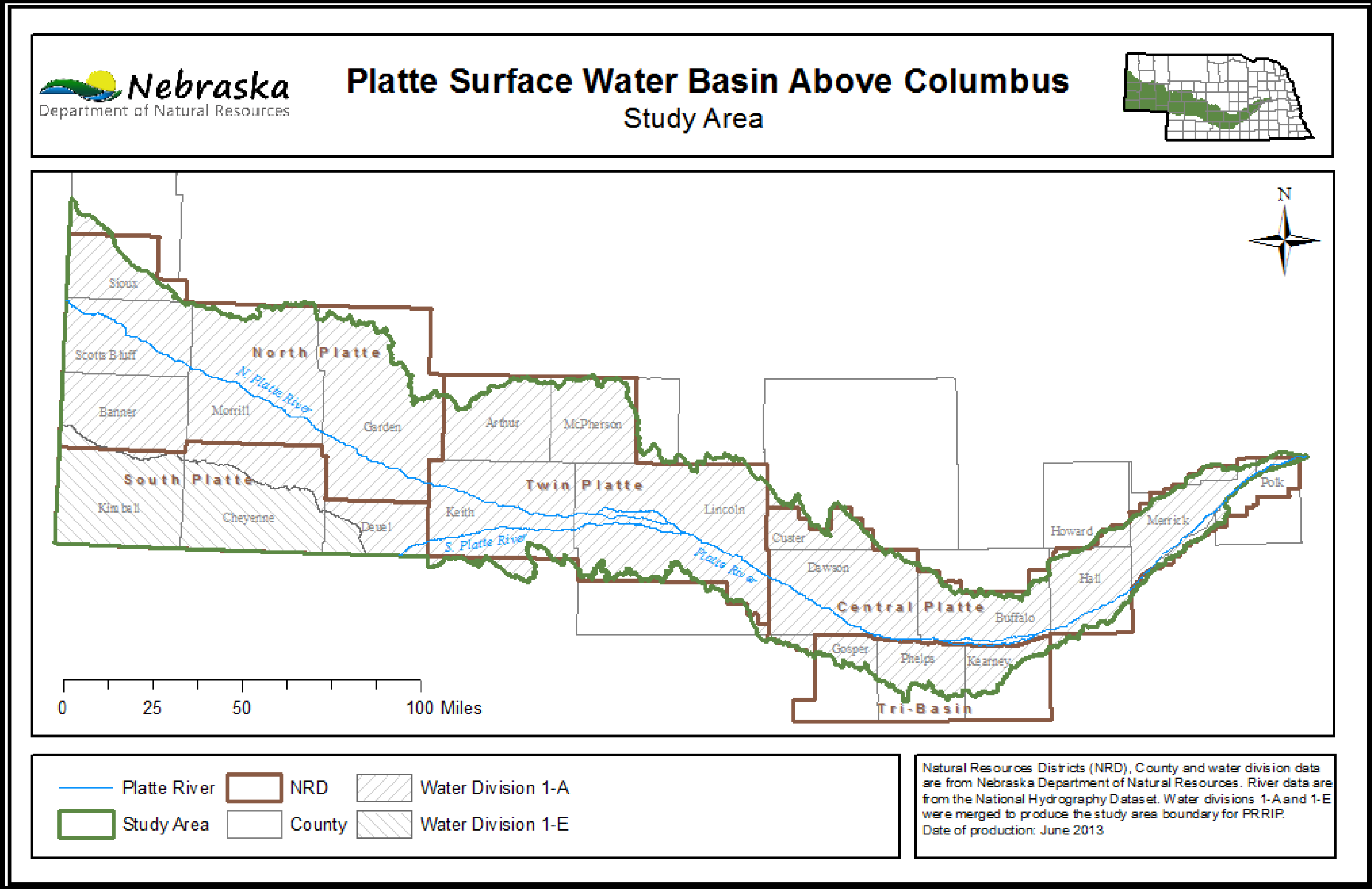
- The NNPD describes the actions Nebraska proposes to take to prevent or mitigate for new depletions to U.S. Fish and Wildlife Service (USFWS) target flows

- The Nebraska Department of Natural Resources (NDNR) has jurisdiction over surface water uses, and requires permits for
  - stream diversions, and
  - on-stream storage reservoirs greater than 15 AF

- For new or expanded sandpits, and new, small reservoirs that do not require permits, NDNR will estimate the cumulative impact on state-protected and target flows
  - Adverse effects will be mitigated by the state

Introduction

– The goal of this work was to estimate cumulative effect of new or expanded sandpits, or new reservoirs on protected flows from 2005-2010



Overview of Methods

- Create a 2005 water body inventory (baseline)
- Create a 2010 water body inventory
- Compare 2010 inventory to baseline
  - New or expanded sandpits
  - New reservoirs

GIS

- Evaluate for permits/mitigation in place
- Use the NRCS calculator to estimate consumptive use change due to new/expanded water bodies with no permits

GIS Methods
Create a baseline water inventory for 2005

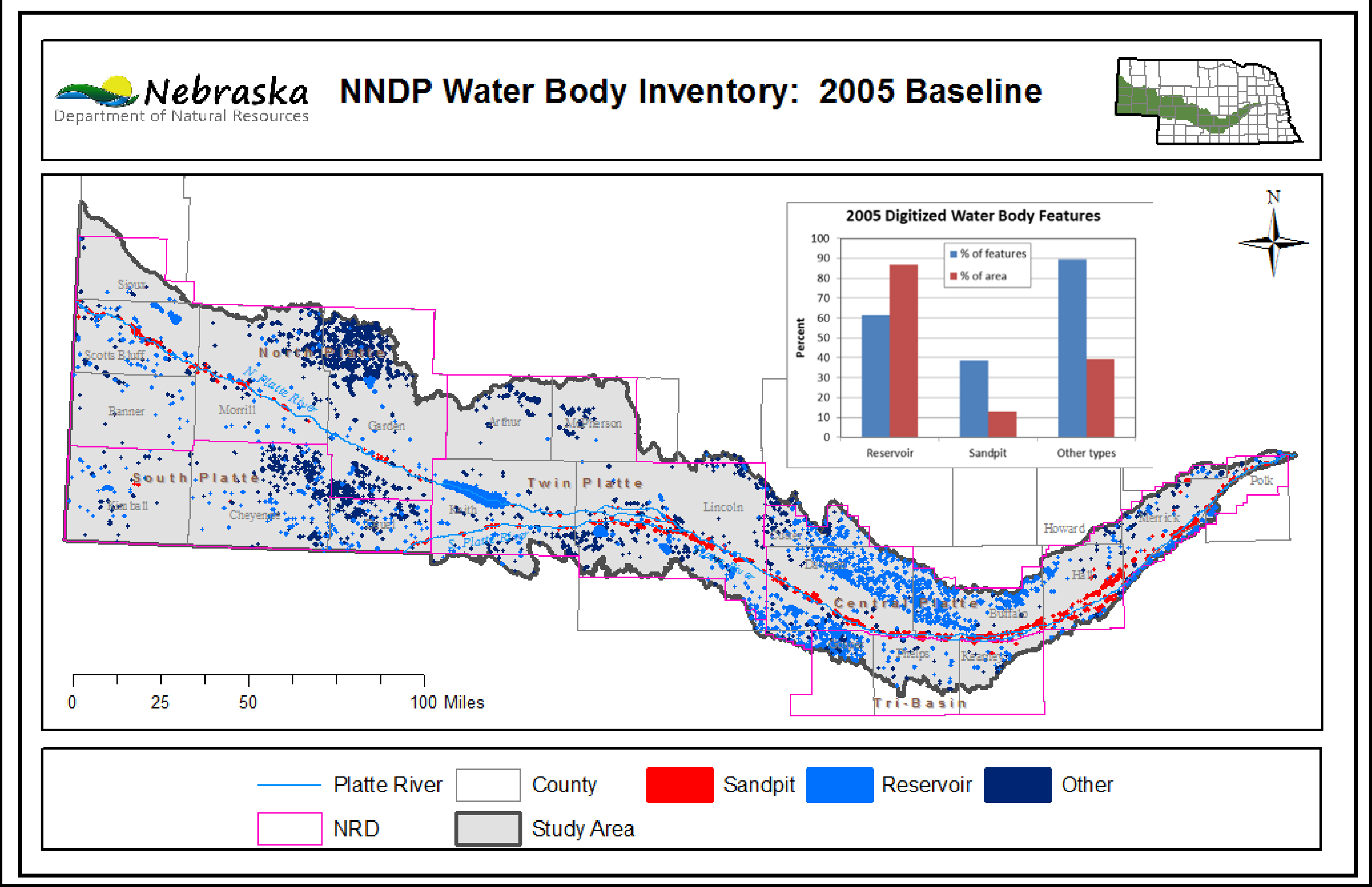
- In 2005, aerial imagery was scanned frame by frame and all water bodies were digitized/ categorized

- From this, the water bodies were categorized
  - Sandpits
  - Reservoirs
  - “Other”

- Resulted in roughly 11,500 features

- Whole inventory took 1200 hours to complete

GIS Methods
Create a baseline water inventory for 2005



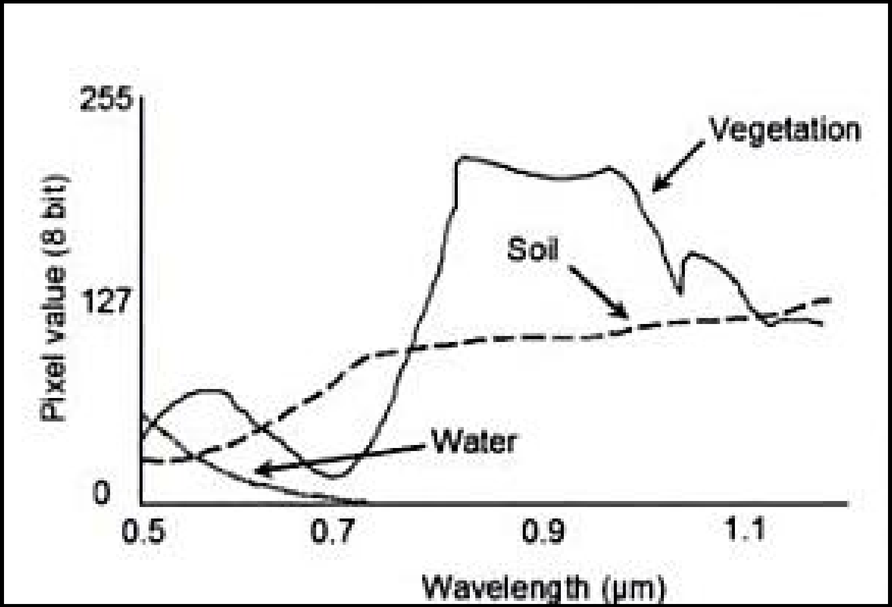
GIS Methods:
Create a 2010 water body inventory

- In 2010, the 2005 baseline methods and final dataset were reviewed, as well as aerial imagery

- 2010 was a much more wet year, resulted in roughly 3-4 times as much water
  - potential for 4000 hours of labor if same methods were employed

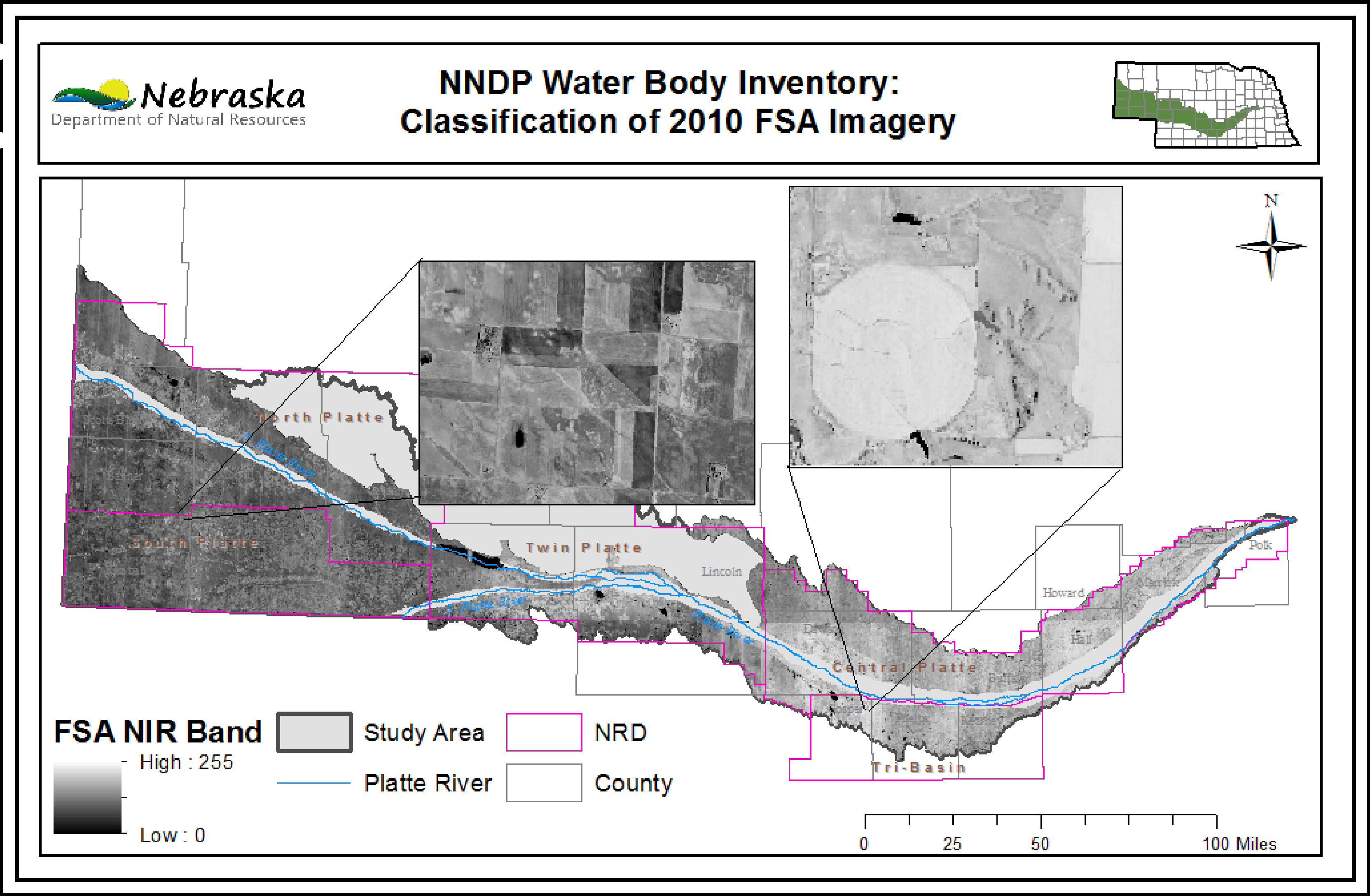
GIS Methods
Create a 2010 water body inventory

- Semi-automatic approach
- Classification of FSA imagery to identify water
  - Utilized Near-Infrared band values

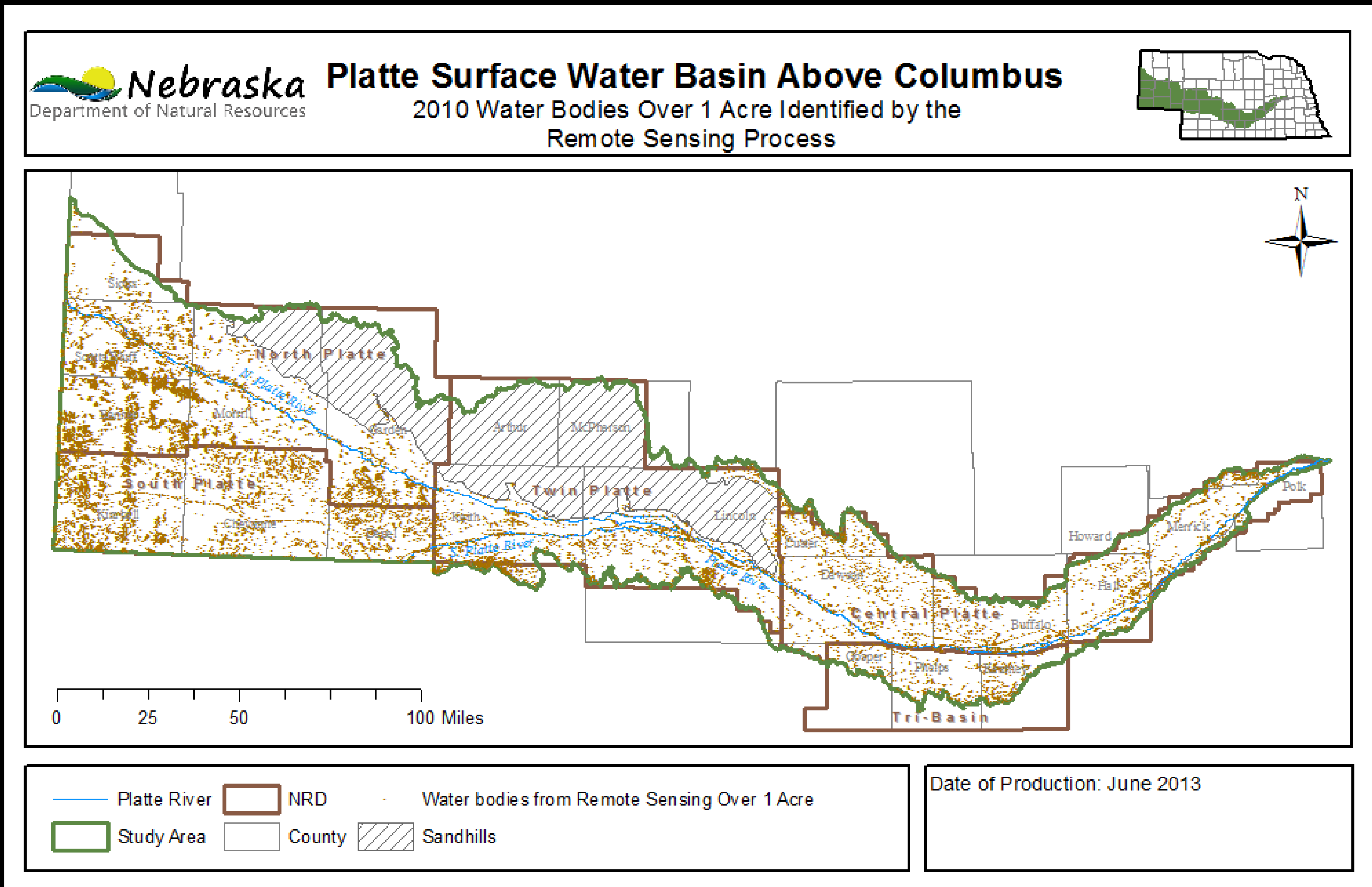


From Mather and Koch, 2011

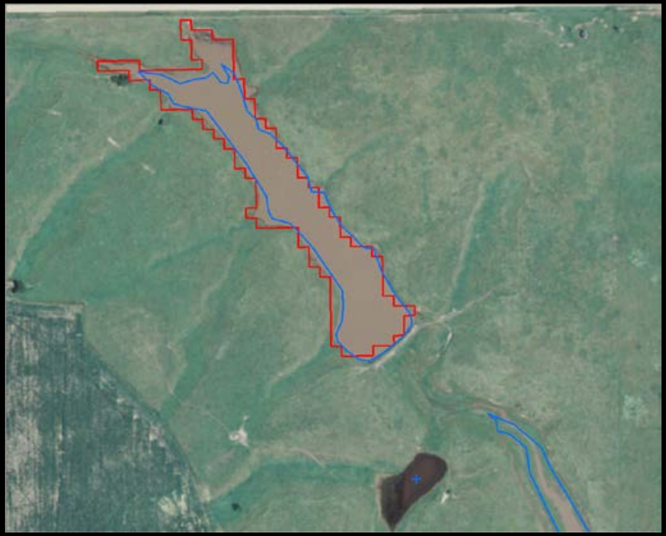
GIS Methods
Create a 2010 water body inventory

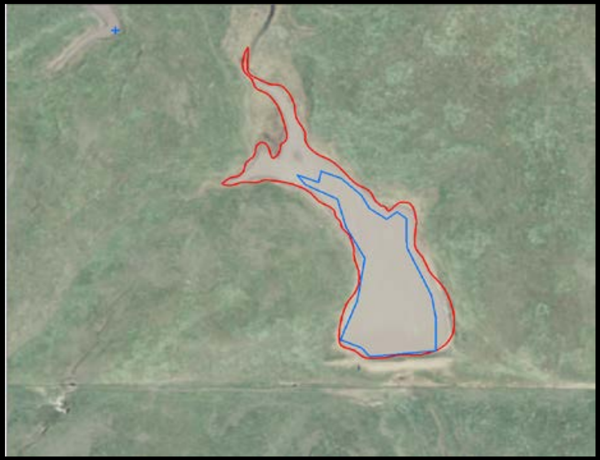


GIS Methods
Create a 2010 water body inventory

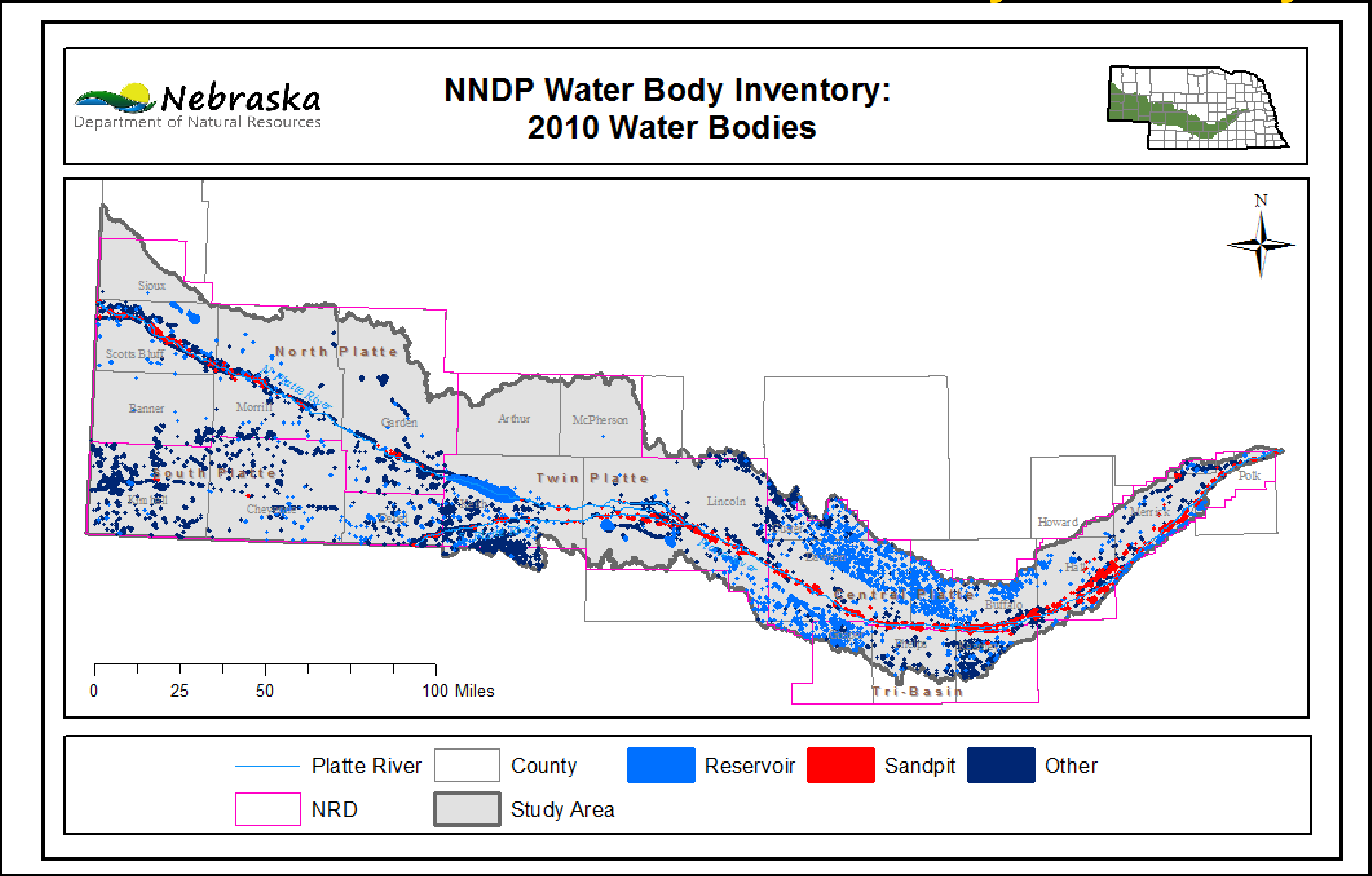


GIS Methods
Manual Editing of Classified Features



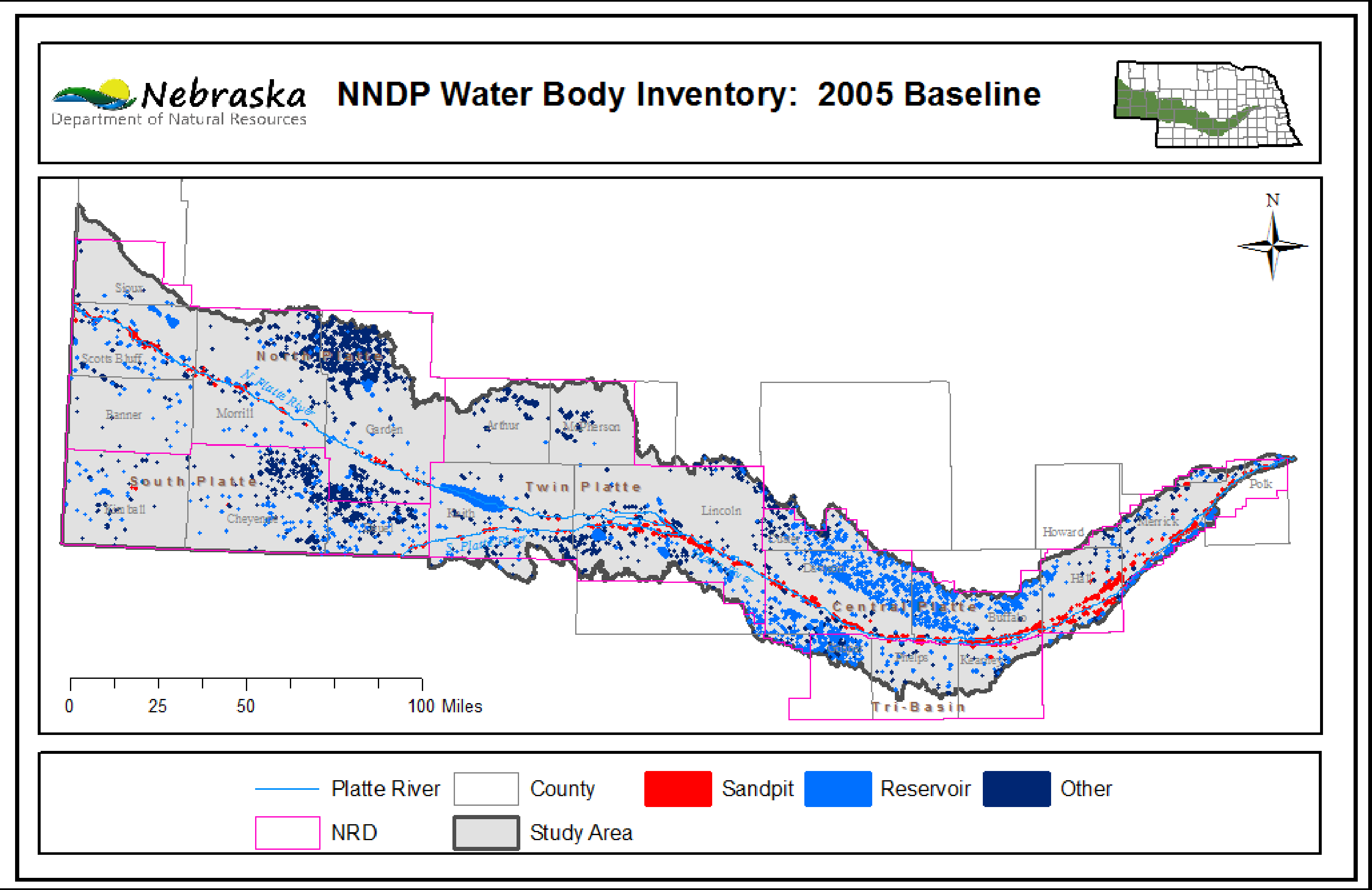


GIS Methods
Classification of 2010 water body inventory

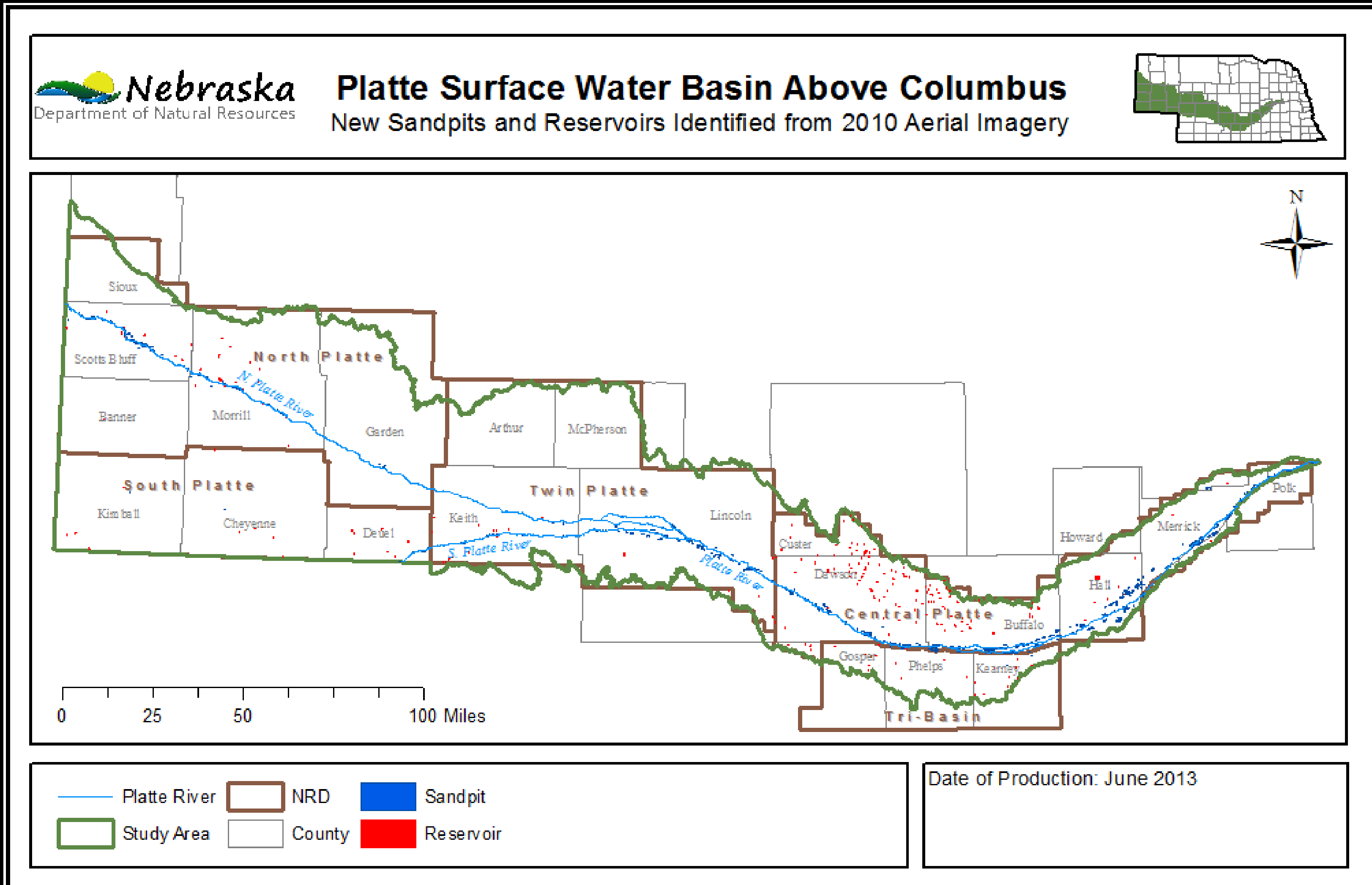


2,583 water bodies classified as sandpits or reservoirs (53,557 acres)

GIS Methods
Overlay with 2005 water body inventory



Potential Sandpits and Reservoirs for Change Analysis



758 sandpits and reservoirs preliminarily designated as changed (3,723 acres)

Criteria for Inclusion in Change Analysis

Reservoirs

- New embankment
- No permits
  - Surface water right or dam safety plan
  - If a right or plan exists, check for depletions and mitigation already in place

Sandpits

- Active gravel pit
- No estimated depletions or mitigation
- Account for land reclamation

Reservoir Change Analysis Criteria: New Embankment

- New embankment physically present after 2005

2005

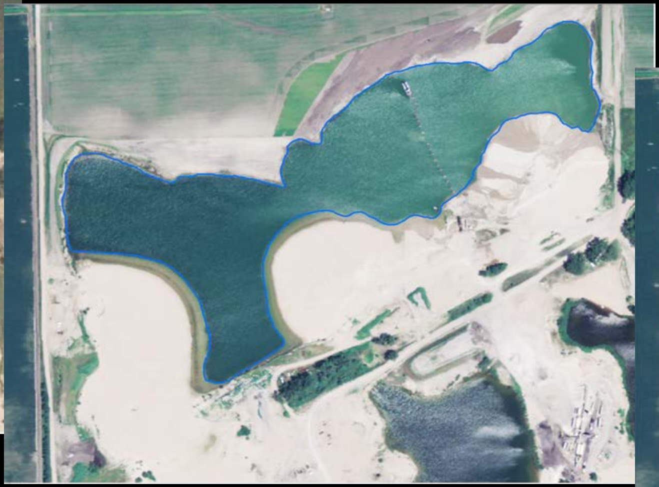
2006

2010

Sandpit Change Analysis Criteria: Activity

- Sandpit criteria
  - Sand around new/expanded sandpits
  - Looked at expanded portions, accounted for reclaimed portions

2005



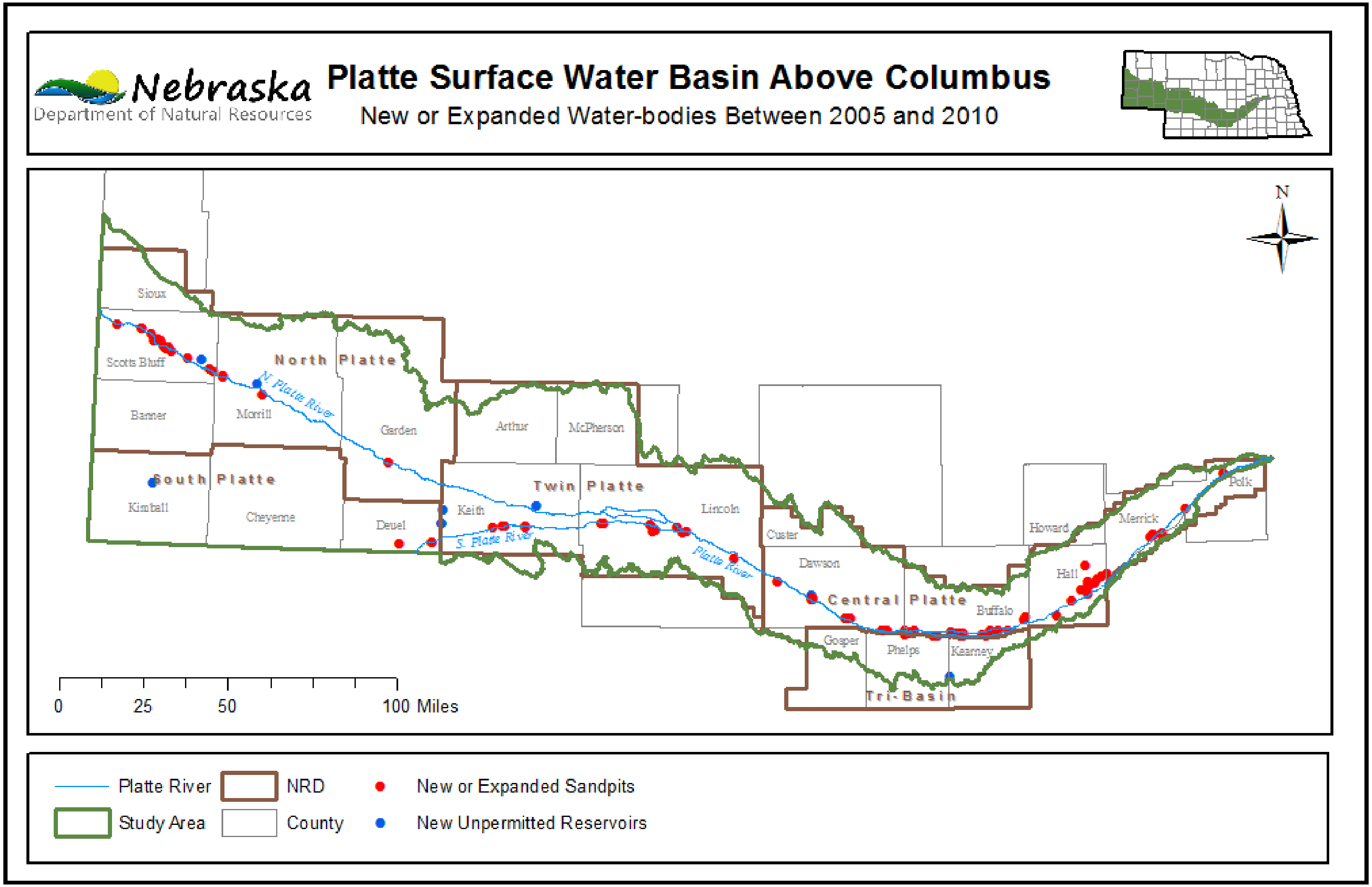
2010

Reduced Areas
Expanded Areas

NRD Review

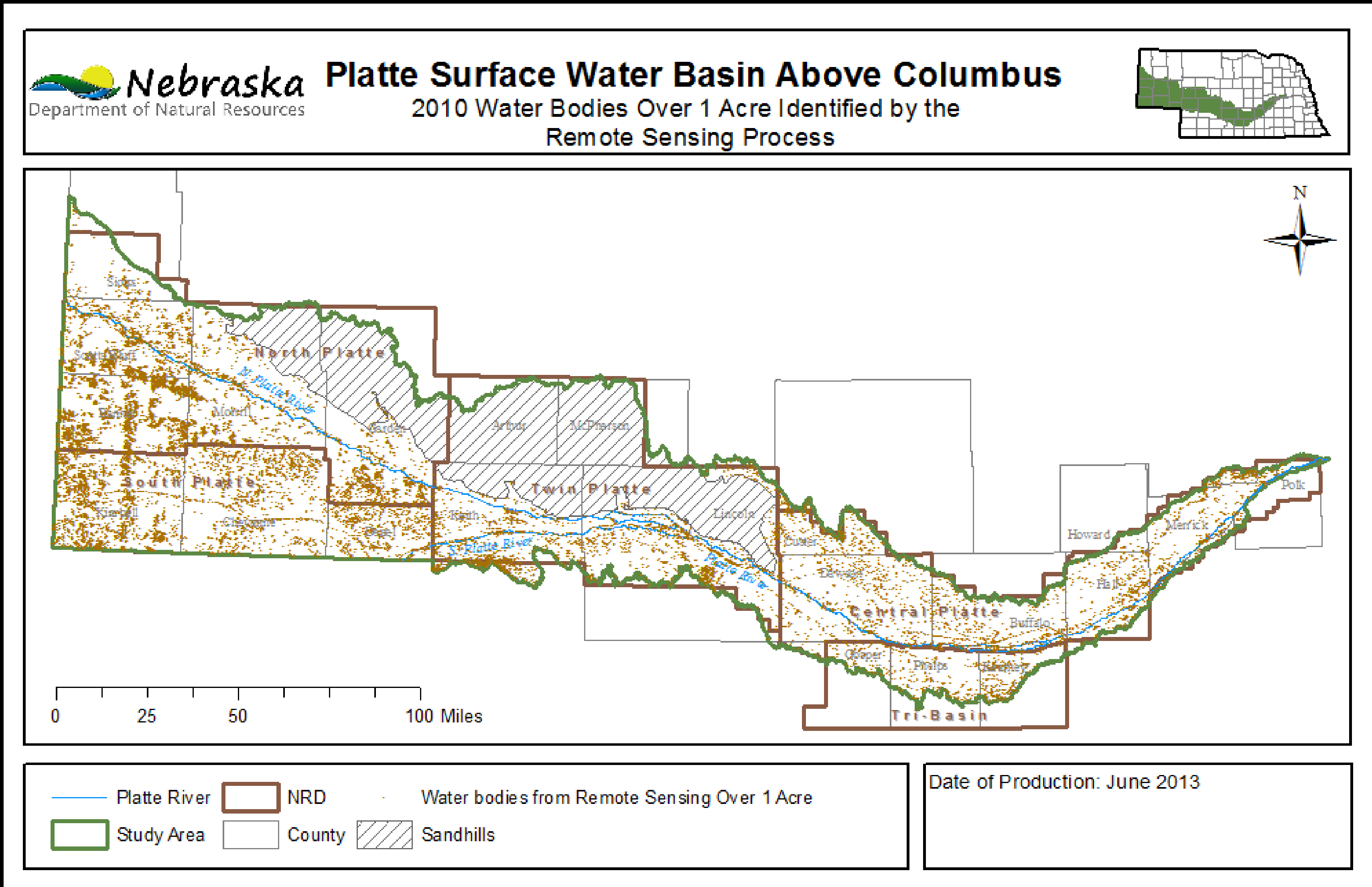
- Features Identified as new or expanded were sent to NRDs for review
- A few features had not changed due to man's activities,
- A few features had been mitigated
- These were removed from subsequent analyses

Sandpits and Reservoirs for ET Change



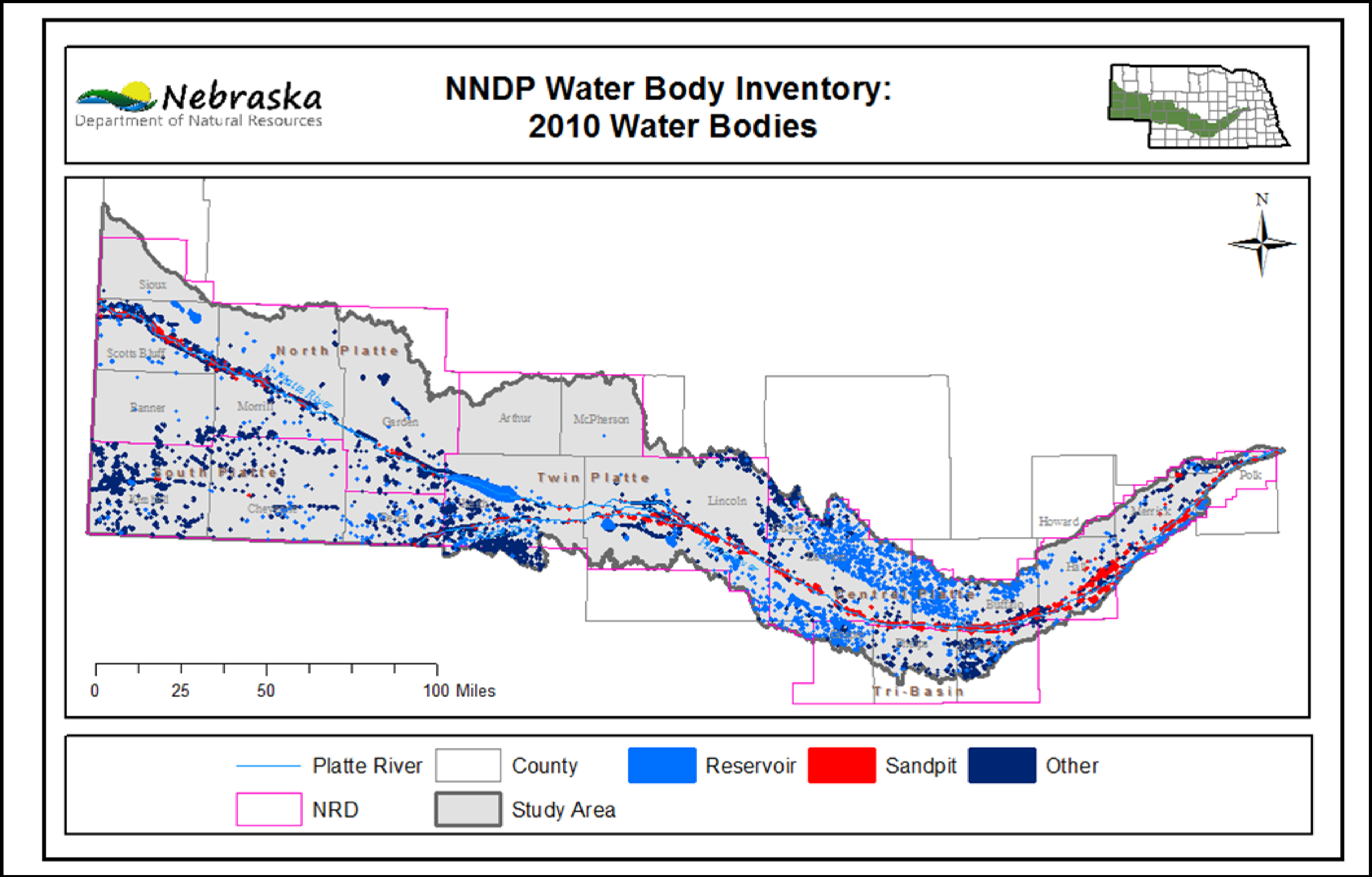
94 sandpits, and 9 reservoirs for change analysis

Synopsis of steps to create water body layer for change analysis



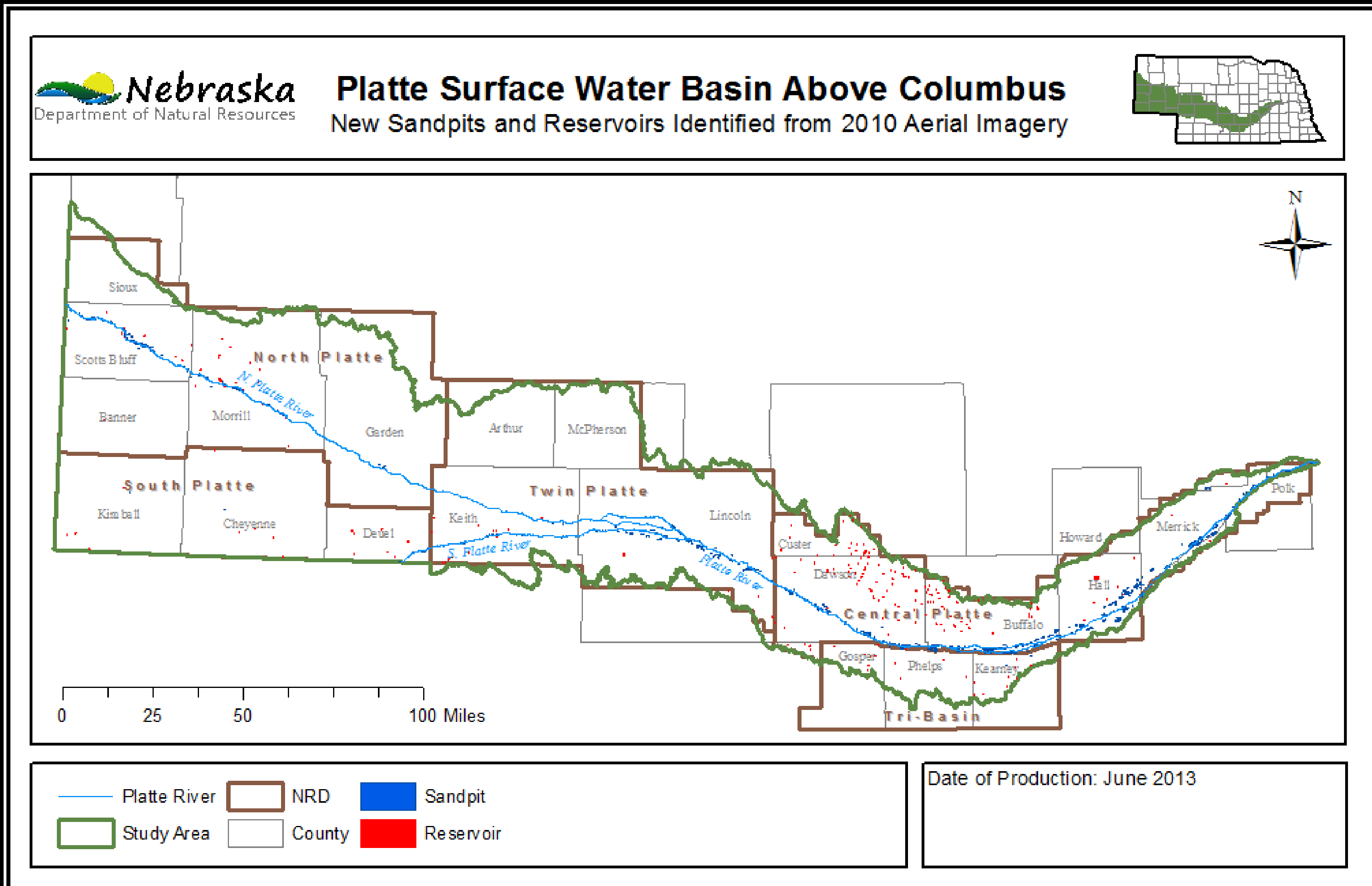
19,043 features (122,431 acres)

Synopsis of steps to create water body layer for change analysis



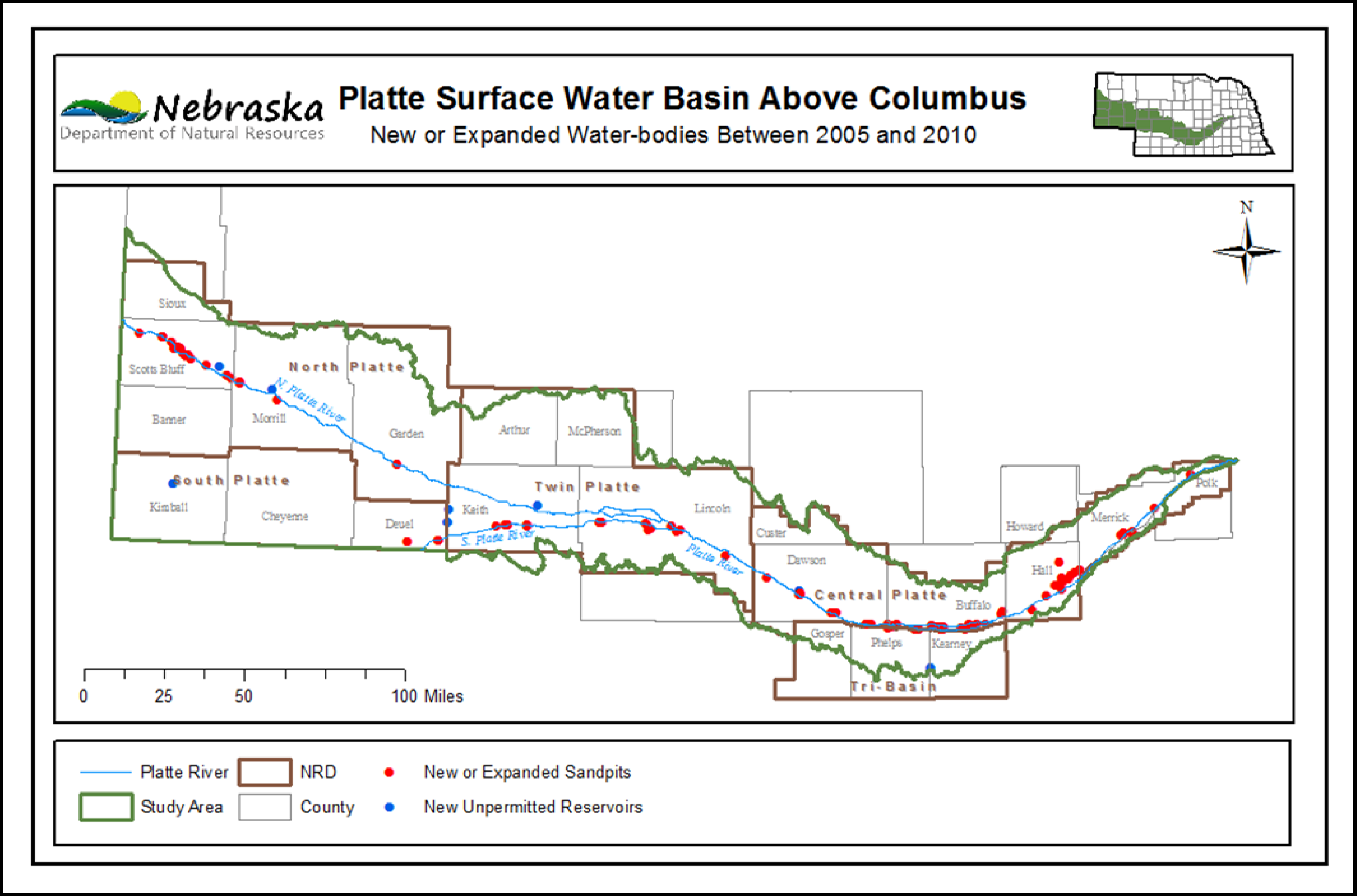
2,583 sandpits and reservoirs (53,557 acres)

Synopsis of steps to create water body layer for change analysis



758 sandpits and reservoirs (3,723 acres)

Synopsis of steps to create water body layer for change analysis



Sandpits: 94 (728 acres); Reservoirs: 9 (19 acres)

Breakdown of evaluated water bodies

Change Analysis Reservoir Identification Process		
Procedure	**Number of Features**	**Area (acres)**
Reservoirs classified from 2010 imagery	1,578	45,507
Reservoirs not included in 2005 inventory	573	1,521
Reservoirs with new embankments between 2005 and 2010	11	405
New reservoirs with permits between 2005 and 2010	(2)	386
New unpermitted reservoirs between 2005 and 2010	9	19

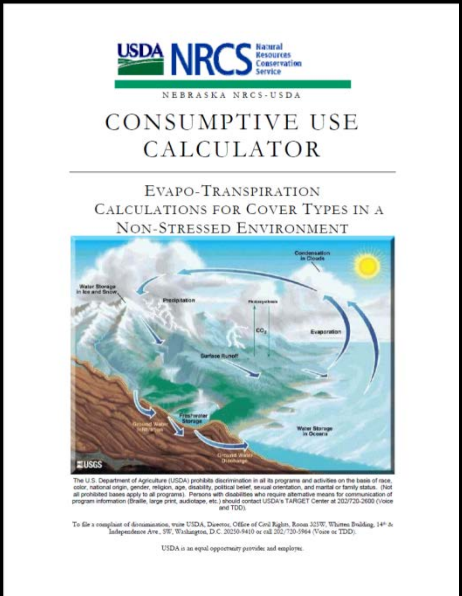
Change Analysis Sandpit Identification Process		
Procedure	**Number of Features**	**Area (acres)**
Sandpits classified from 2010 imagery	1,005	8,050
Sandpits with area change from 2005	185	2,202
New/expanded sandpits identified from visual analysis	98	736
New sandpits with mitigation	(4)	8
New/expanded sandpits between 2005 and 2010	94	728

Methods

Evapotranspiration (ET) estimation using NRCS ET calculator

NRCS ET Calculator

- Created by Natural Resources Conservation Service (NRCS)
- Consumptive use change assessment in Platte basin
- Average monthly ET of 46 land covers
  - Grasslands
    grass cool mid; grass cool short; grass cool tall; grass warm mid; grass warm short; grass warm tall; grass pasture good; grass pasture bad
  - Wetlands
    wet tall grasses; wet cattail/bulrush moist; wet cattail/bulrush standing water; wet linear; wet short veg moist; wet short veg standing water
  - Water
    water shallow; water deep
- March to November ET


USDA NRCS Natural Resources Conservation Service

NEBRASKA NRCS-USDA

CONSUMPTIVE USE CALCULATOR

EVAPO-TRANSPIRATION CALCULATIONS FOR COVER TYPES IN A NON-STRESSED ENVIRONMENT

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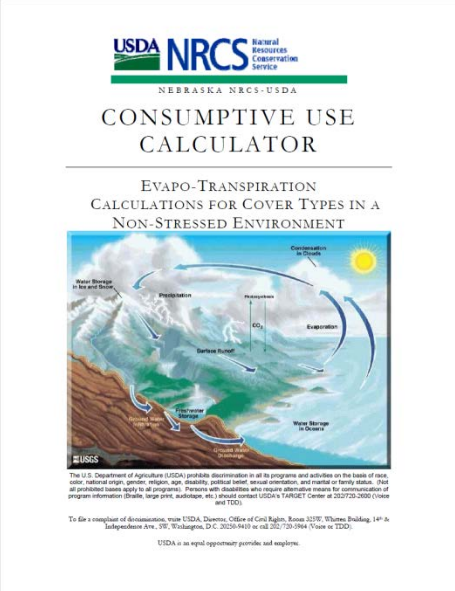
Methods: ET Calculation

- Data for ET Calculator
  - Location and acres
    - GIS process
  - Soil type
    - STATSGO (horizon 1)
  - Land cover
    - CALMIT 2005 land cover dataset
    - UNL CSD native vegetation
  - Location in ET climate areas
    - NRCS consumptive use calculator guide


USDA NRCS Natural Resources Conservation Service

NEBRASKA NRCS-USDA

CONSUMPTIVE USE CALCULATOR

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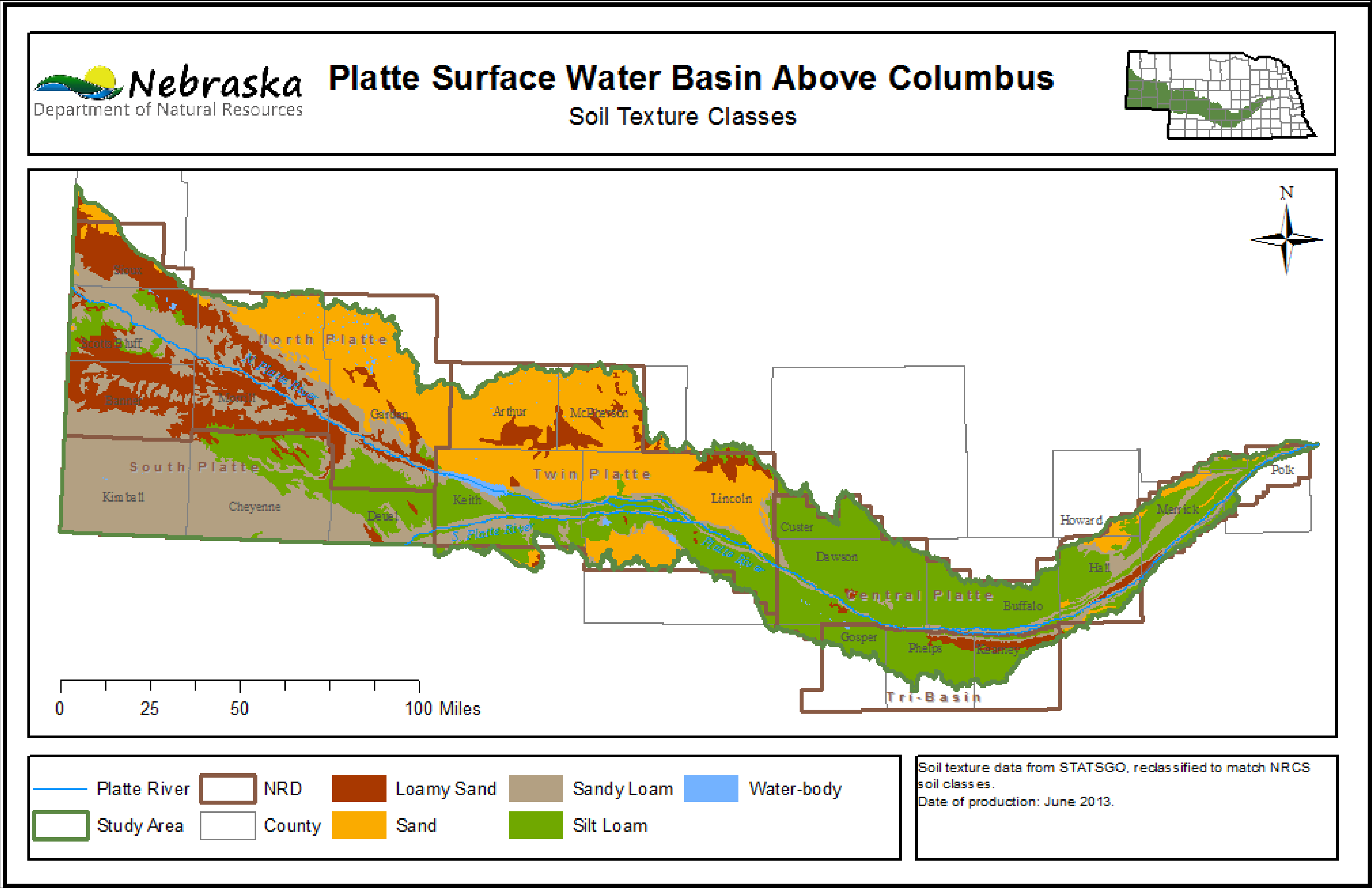
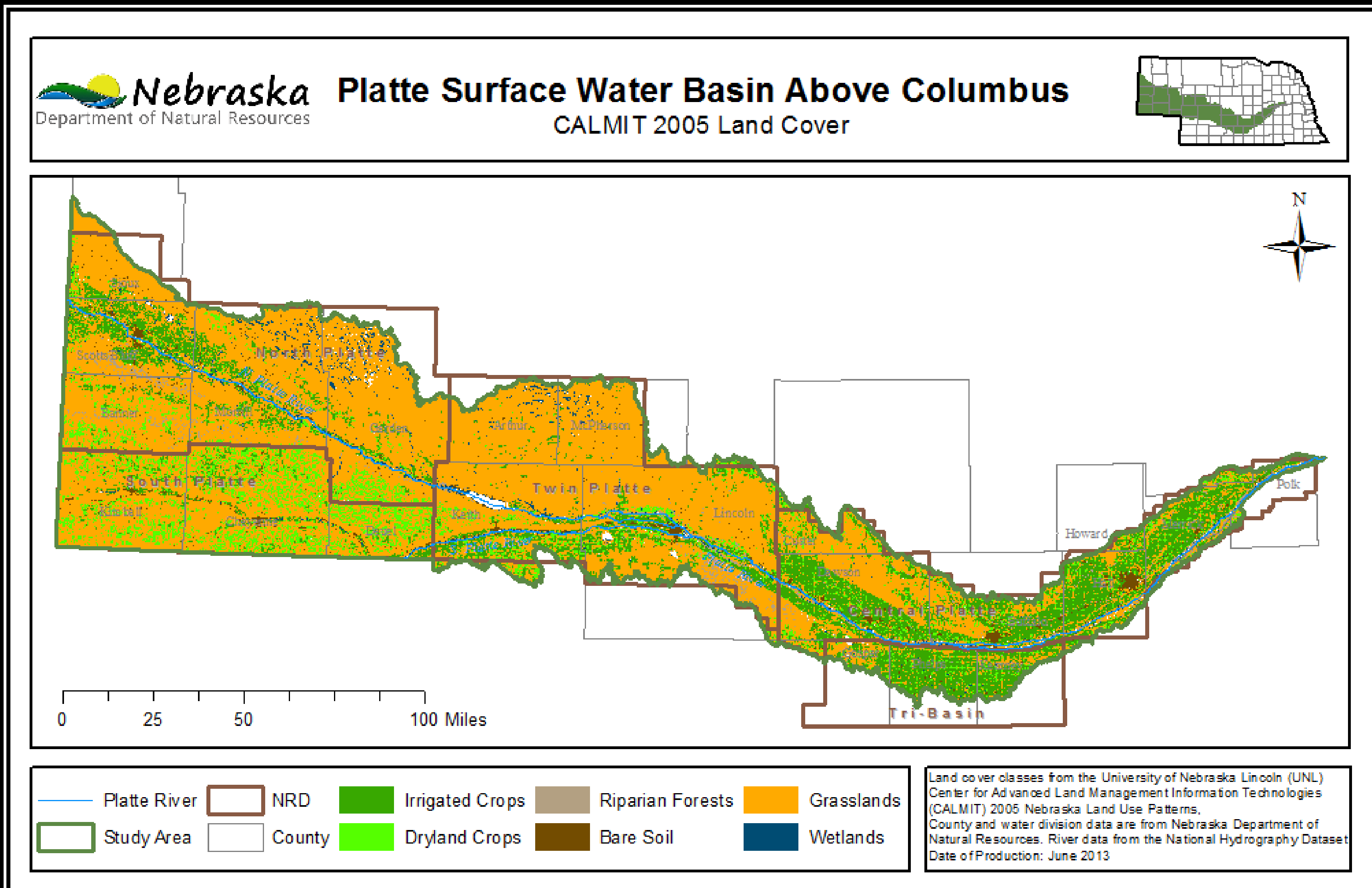
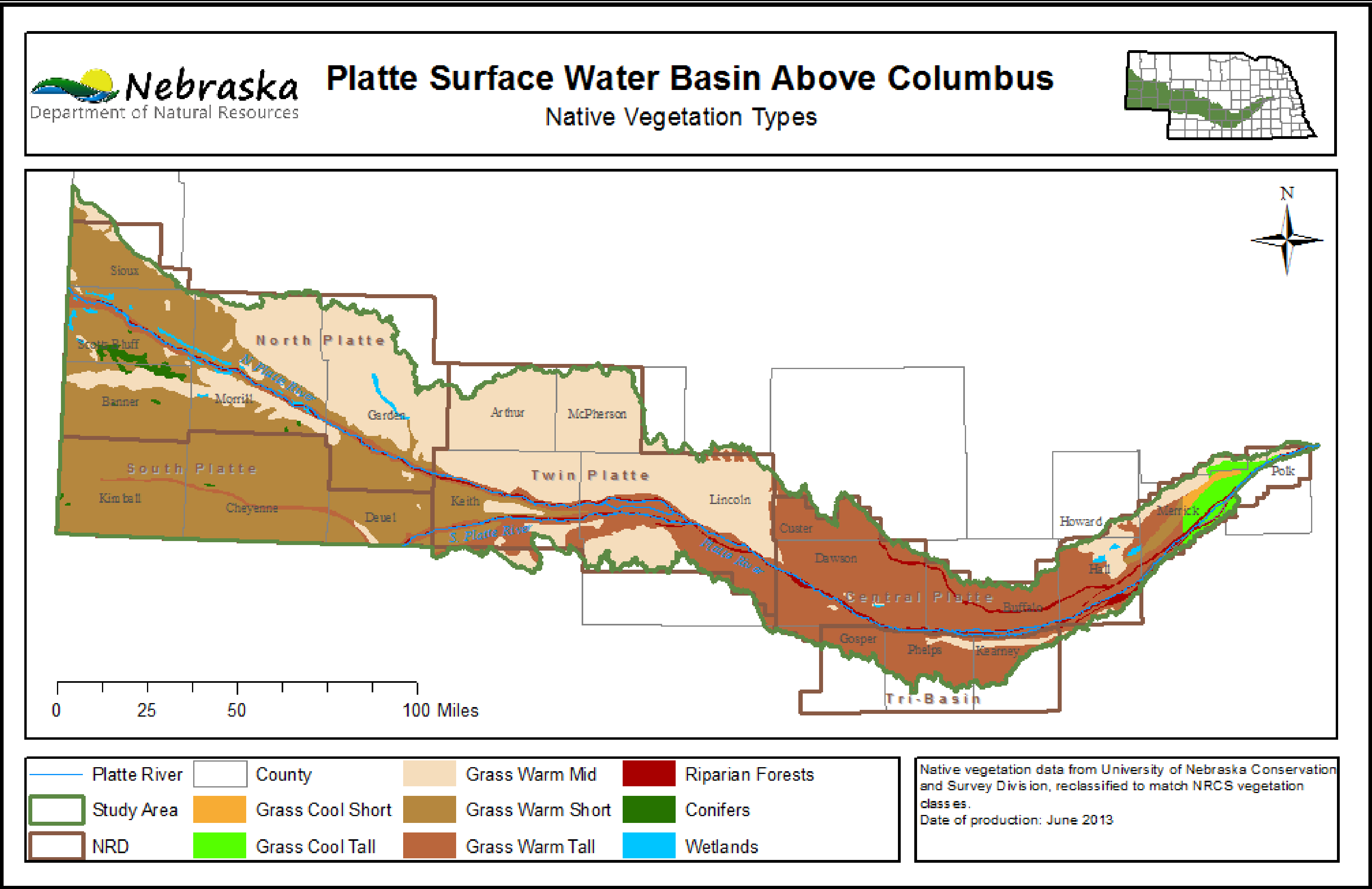
Methods: ET Calculation



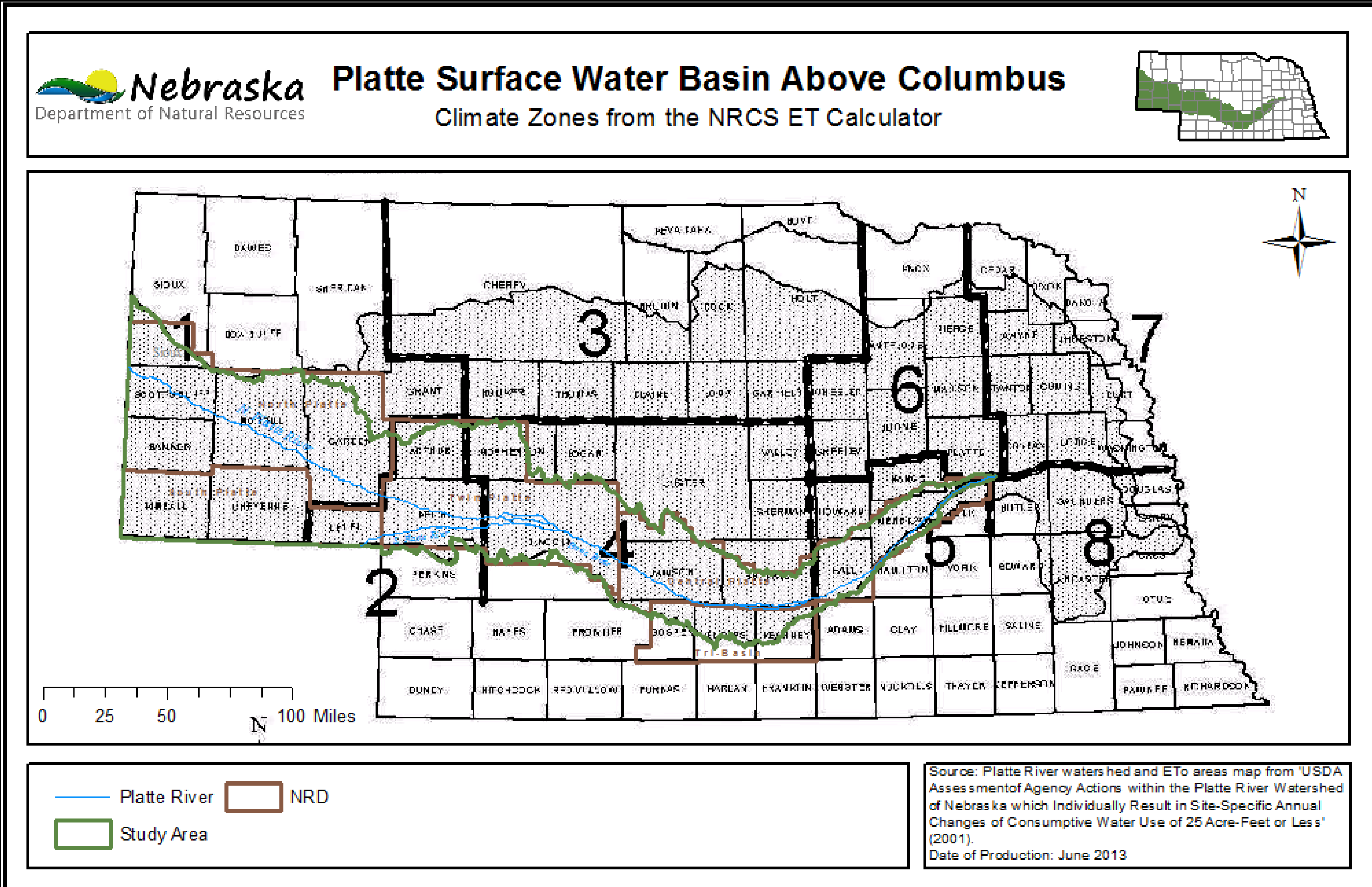
Methods: ET Calculation



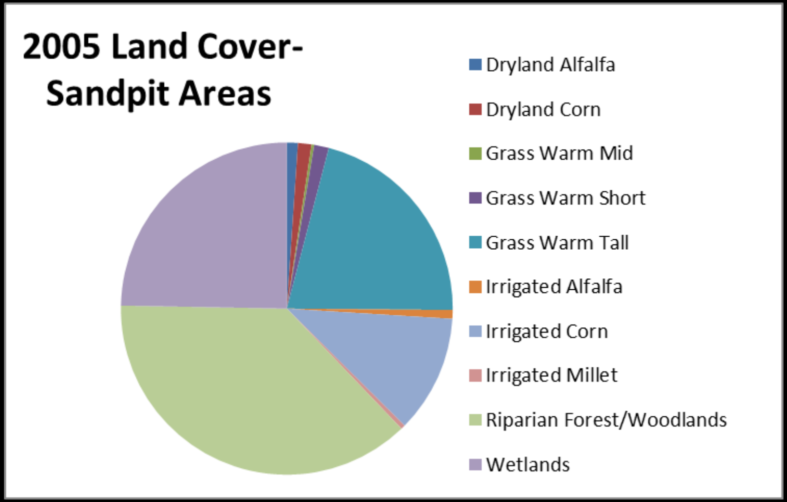
Methods: ET Calculation

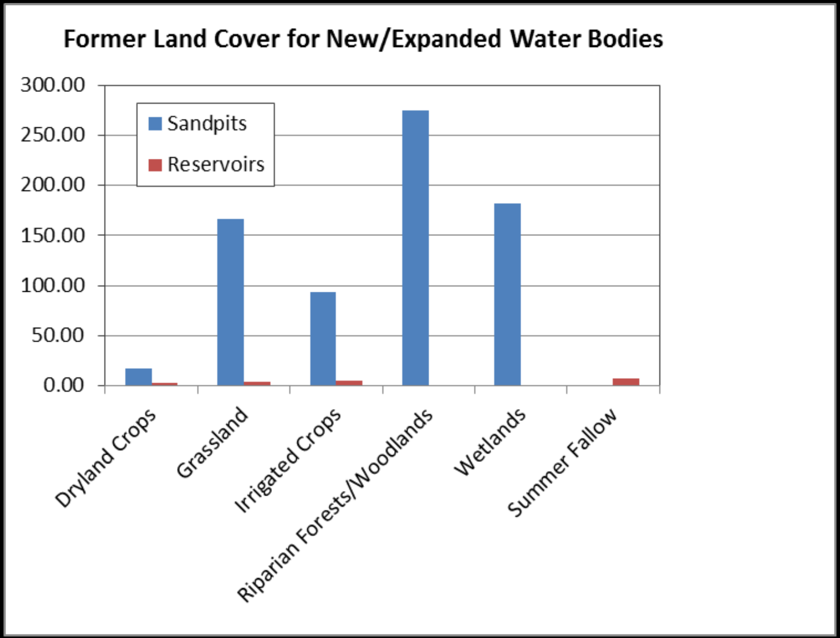


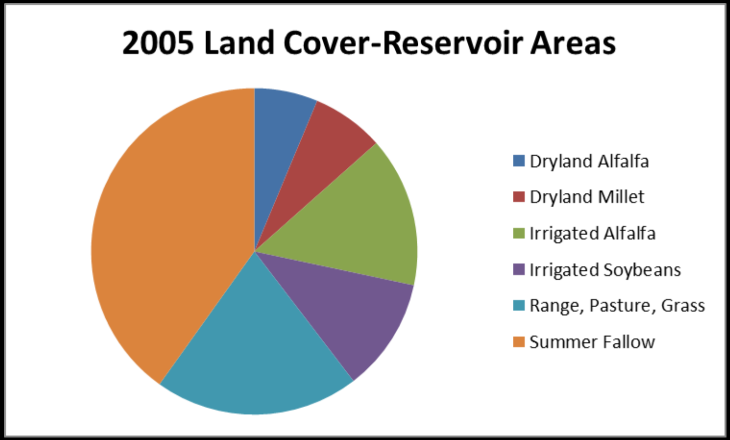
Methods: ET Calculation



Methods: Prior Land Use for ET Calculation



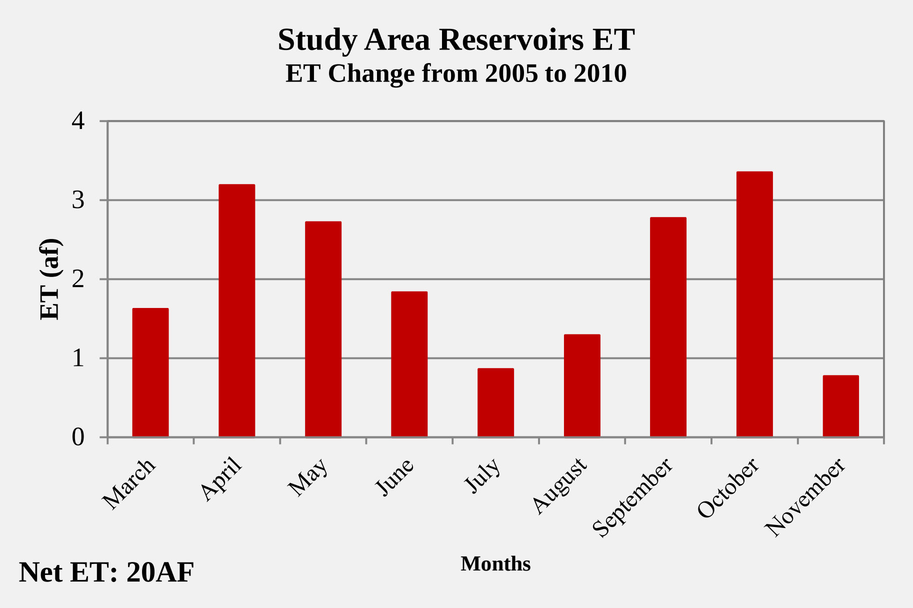


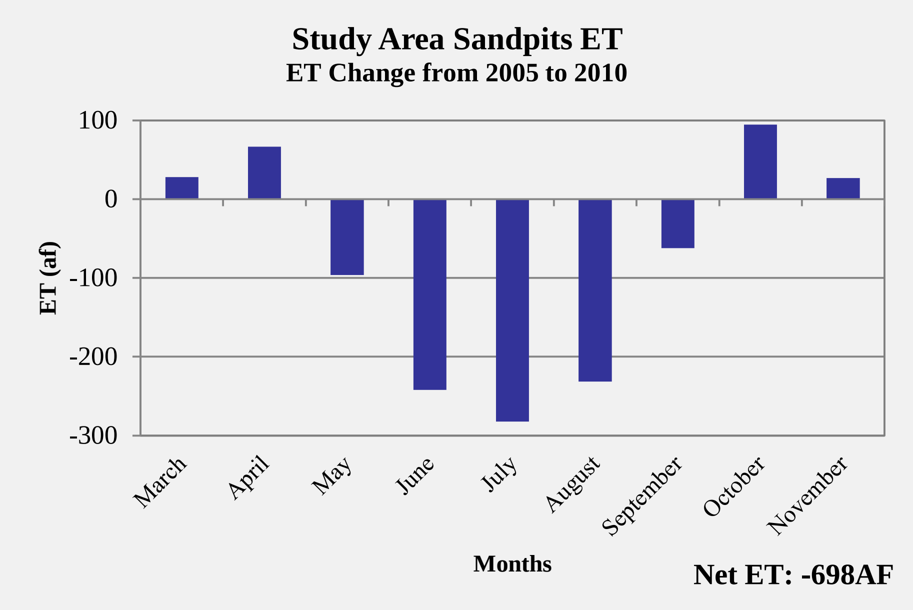


Methods: ET Calculator Assumptions/Decisions

- 2005 land cover
  - CALMIT land cover
    - UNL CSD native grasses
  - Wet tall grasses for wetlands
  - Average ET of cottonwoods and willows for riparian trees
- 2010 land cover
  - Shallow water (<1m) for reservoirs
  - Deep water (>1m) for sandpits
- Reclaimed sandpit land
  - 2010 land cover: Sand
- Irrigation application timeframe: May to September

Results: ET Change 2005 to 2010

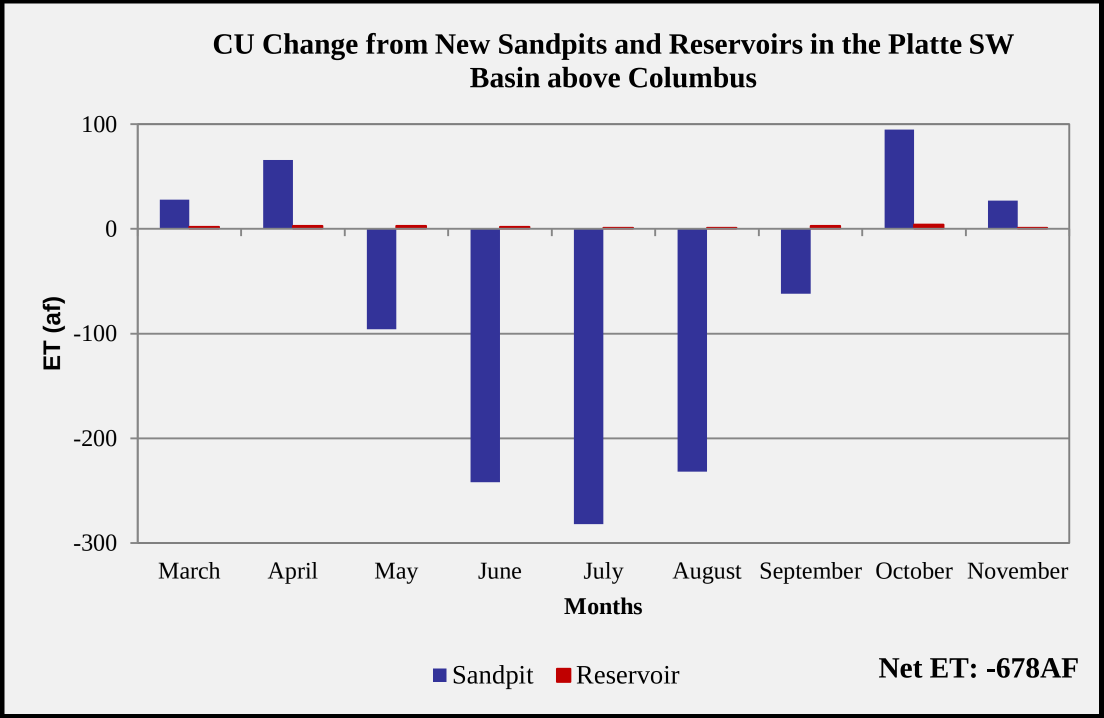




20af ET increase from new unpermitted reservoirs

698af ET decrease from new or expanded sandpits

Results: ET Change 2005 to 2010



Overall ET decrease of 678af per year from sandpits and reservoirs

Summary

- Used geospatial technologies to identify small man-made water bodies
- Used NRCS calculator to estimate ET due to changed land cover.
- 747 acres of new reservoirs and new/expanded sandpits
- Increase in ET during all months for reservoirs
- ET increase in non-irrigation months and decrease in irrigation months for sandpits
- Overall annual decrease of 678af in consumptive use via ET
- 2500 hours to create inventory and run ET calculations

Nebraska Department of Natural Resources

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Nebraska Department of Natural Resources

References

Mather and Koch, 2011. Computer Processing of Remotely-Sensed Images: An Introduction, Fourth Edition. John Wiley & Sons, Ltd, Chichester, UK. p. 142.

NRCS Consumptive Use Calculator, online at http://dnr.nebraska.gov/iwm/prrip-nrcs-consumptive-use-calculator-report

Data Sources

- 2005 Farm Service Agency Digital Aerial Imagery: http://dnr.ne.gov/databank/DigitalImagery.html
- CALMIT 2005 Statewide Land Use Dataset: http://calmit.unl.edu/2005landuse/statewide.php
- UNL CSD Native Vegetation Dataset: http://snr.unl.edu/data/geographygis/NebrGISland.asp
- National Hydrography Dataset: http://dnr.ne.gov/databank/nhd.html
- STATSGO Soil Data: http://www.dnr.ne.gov/databank/statsgo1.html
- NRCS ET Areas: NRCS Consumptive Use Calculator http://dnr.nebraska.gov/iwm/prrip-nrcs-consumptive-use-calculator-report