Lower Platte Missouri Tributaries Model

NRD Spring Water Conference

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Outline

- Lower Platte Missouri Tributaries (LPMT) Model Construction Timeline
- LPMT Model Construction Domain and Boundaries
- Discussion of Model Packages
- Calibration and Sensitivity Analysis
- Results –Missouri Tributary Zones and a Single Zone

Why Was the LPMT Model Constructed?

- Provide a regional numerical groundwater model to aid in the study of the impact of pumping on streams in the area
- Before the development of the LPMT model there was no regional model encompassing the eastern region of Nebraska. The LPMT model covers the northern and central part of that region
- Region contains complex hydrogeologic features which range from the High Plains Aquifer in the western side, to alluvial aquifers near the major streams, and local perched and semi-perched aquifers in regions containing glacial till

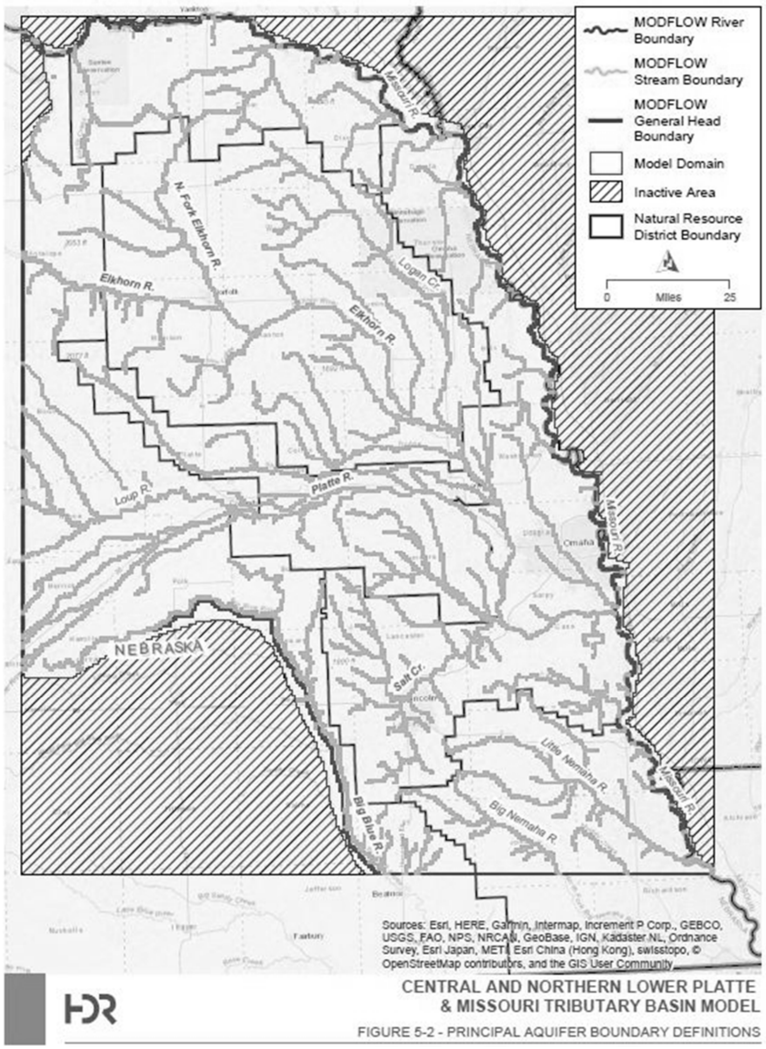
LPMT Model Construction Timeline

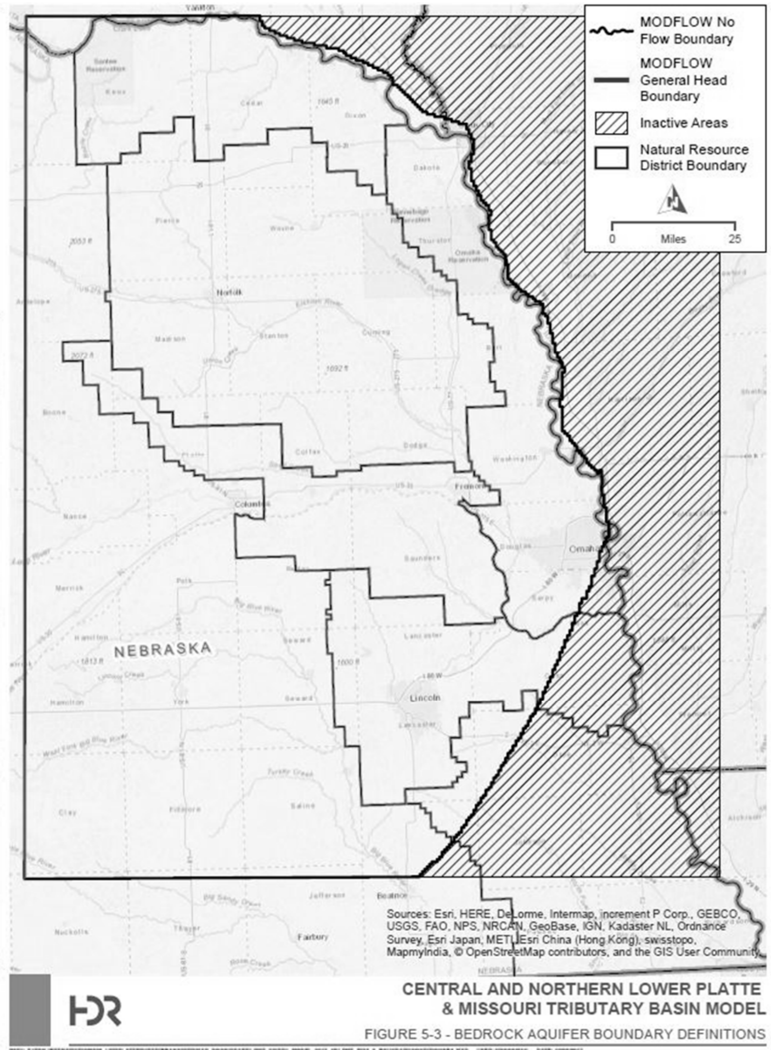
- Three HDR reports from 2012, 2013, and 2014 provided the basis for the development of the model
- Initial model work started in July of 2014. Model development was contracted out to HDR
- First version of the model was finished late 2016 and was reviewed by Olsson Associates. Revisions requested included separating the evapotranspiration from the watershed model to an EVT package, incorporating pilot points, and modifing the zonation constraints
- Final model incorporating revisions from the review was finished December of 2018

LPMT Model Construction Domain and Boundaries

- Layers
  - Model contains two layers where Layer 1 represents the principle aquifer and Layer 2 represents various bedrock aquifer units
- Grid
  - Consists of 350 Rows and 282 Columns
  - ½ Mile by ½ Mile cells
  - 64,347 active cells in Layer 1
  - 69,168 active cells in Layer 2
- Stress Periods – January 1960 through December 2013
  - 1 Steady State, 26 Transient Annual, 336 Transient Monthly
- Packages
  - Well, Recharge, Stream Flow Routing, River, and Evapotranspiration

LPMT Model Construction Domain and Boundaries

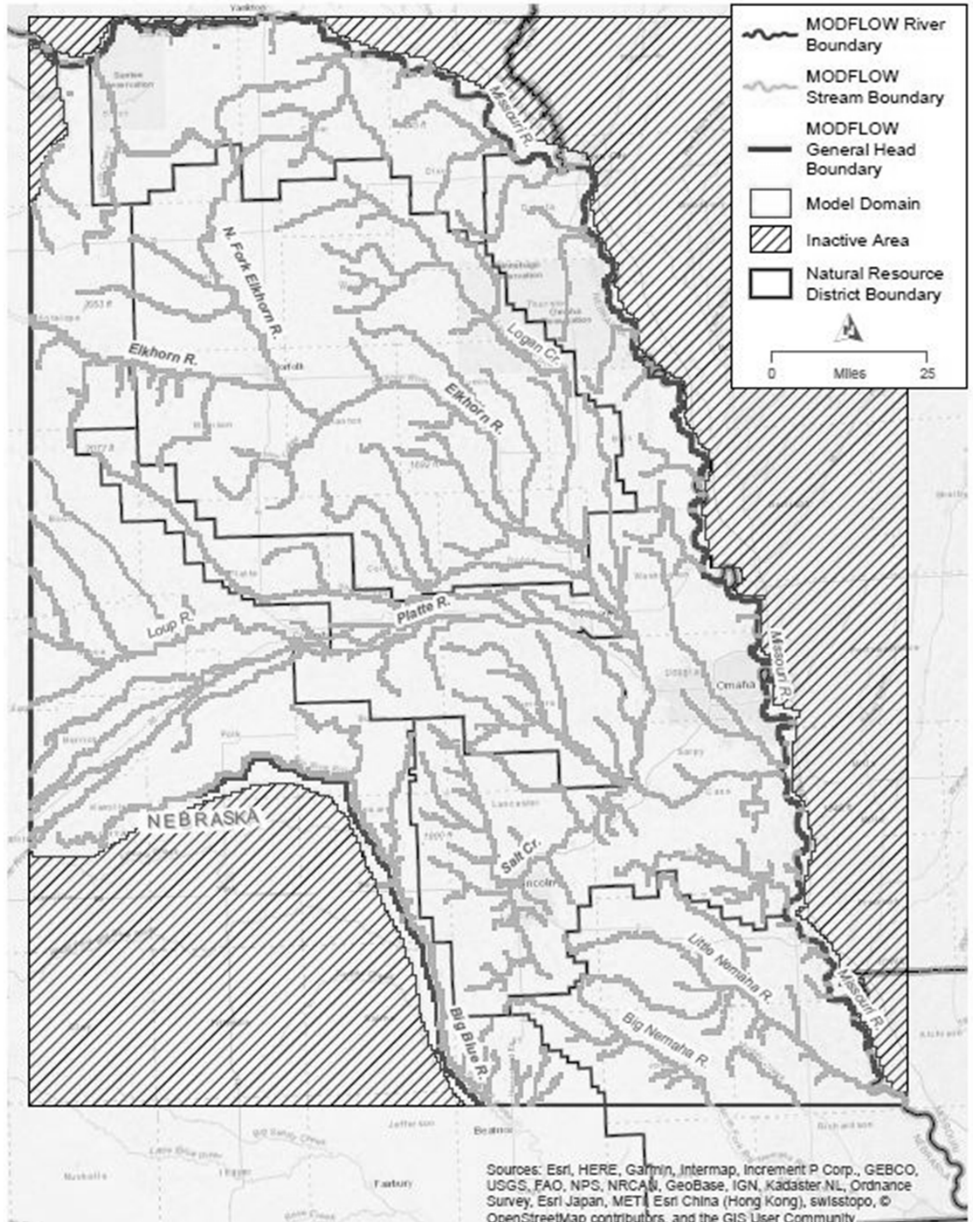




Streams

- Represented internally by the Stream Flow Routing Package (SFR)
- Cells containing perennial streams were selected to be stream cells
- Baseflow of streams entering the model domain were calculated at gaging stations to aid water budget
- SFR allows for stream drying and rewetting as well as creating a water budget term for calculating aquifer/stream exchange

Streams



HDR

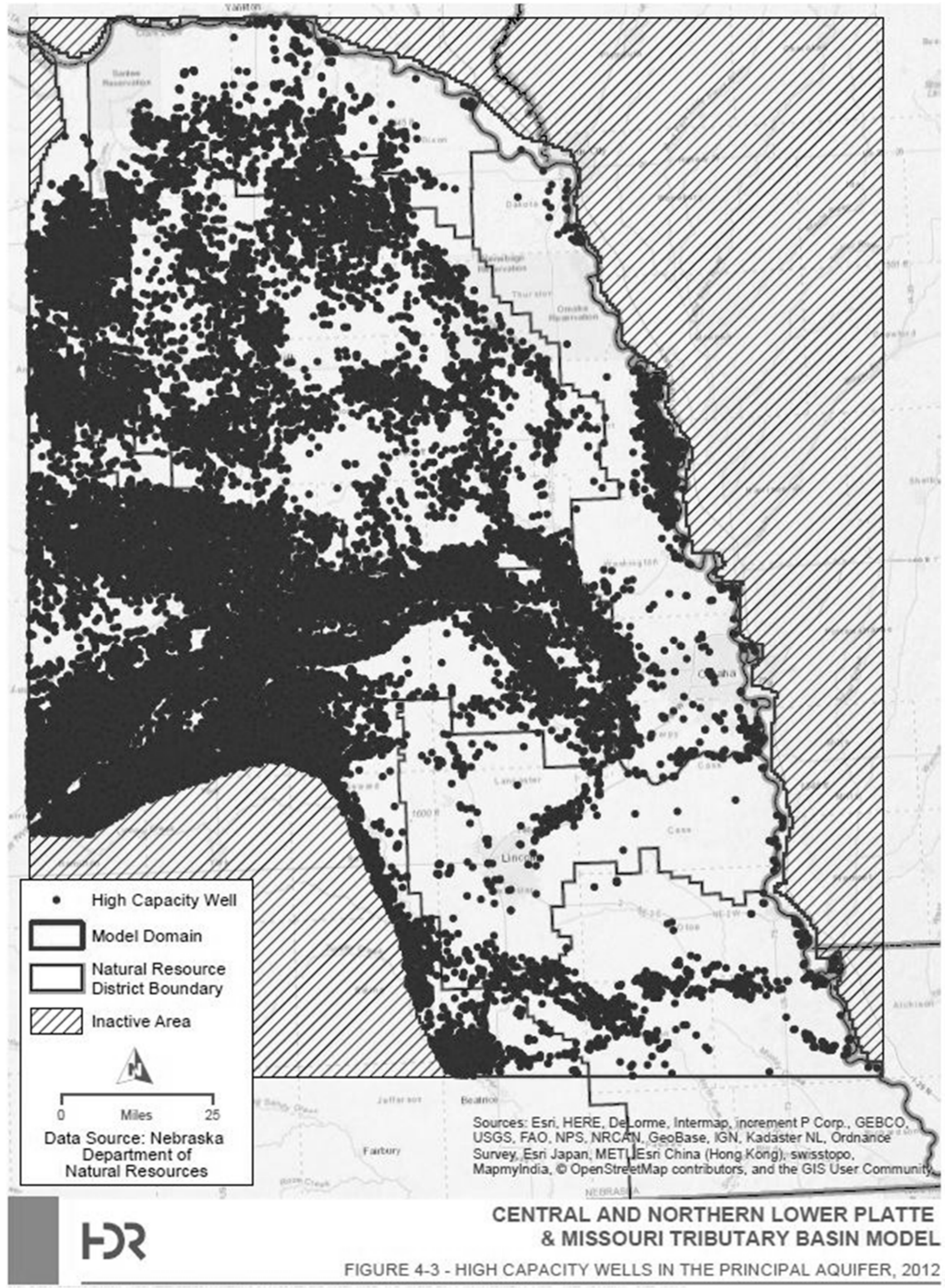
CENTRAL AND NORTHERN LOWER PLATTE & MISSOURI TRIBUTARY BASIN MODEL

FIGURE 5-2 - PRINCIPAL AQUIFER BOUNDARY DEFINITIONS

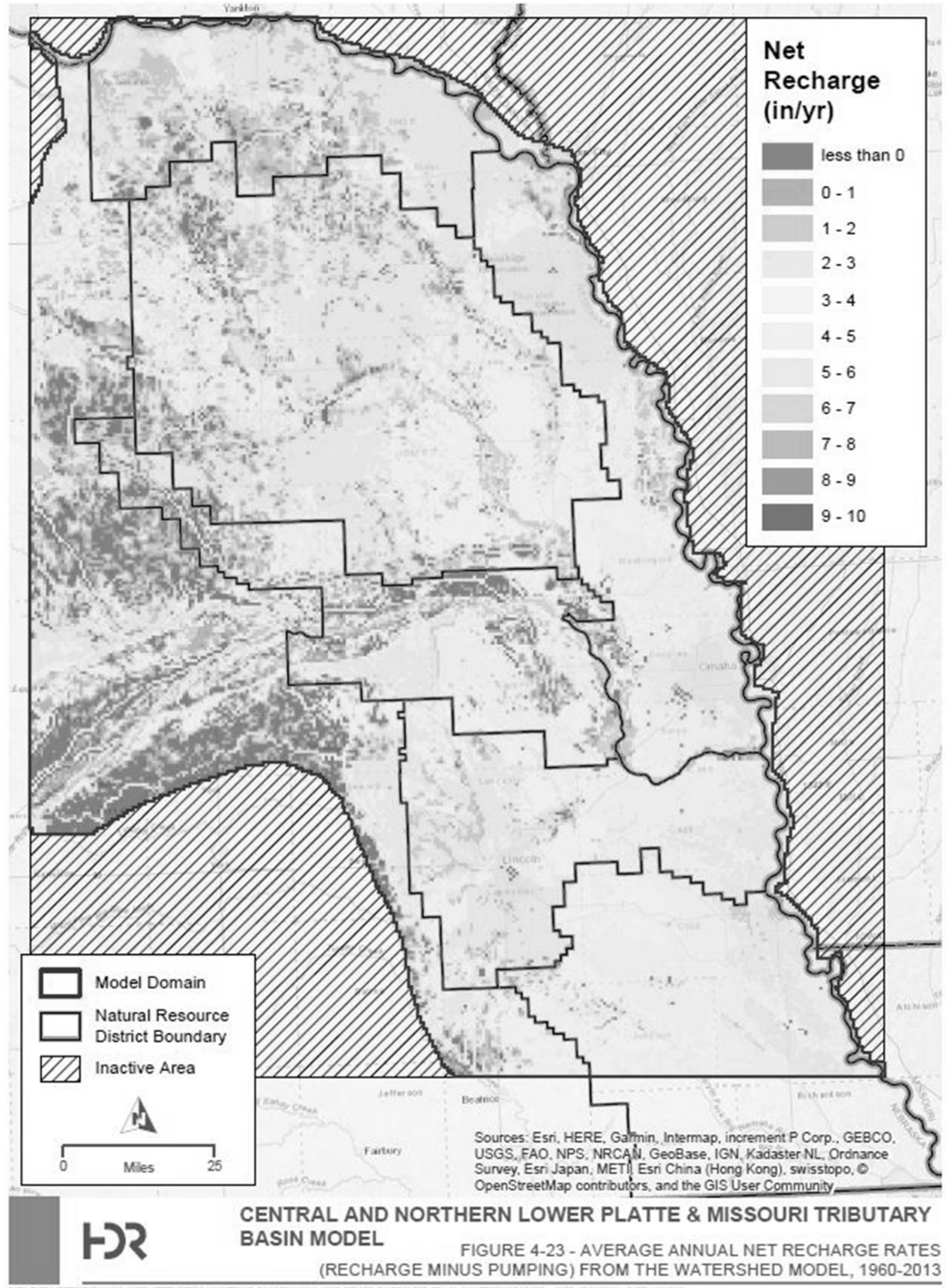
Watershed Model Outputs

- Four major components to the Watershed Model
- Climate model
  - Uses precipitation, temperature, and reference ET to generate inputs for the regionalized soil water balance model
- Soil water balance model – CROPSIM
  - Uses climate model data, soil data, and cropping information to generate the net irrigation requirement
- Spatial and temporal distribution of CROPSIM results
- Regionalized soil water balance model
  - Develops recharge and pumping estimates based on CROPSIM results
- Output Well and Recharge packages for the groundwater model

Watershed Model Outputs - Wells



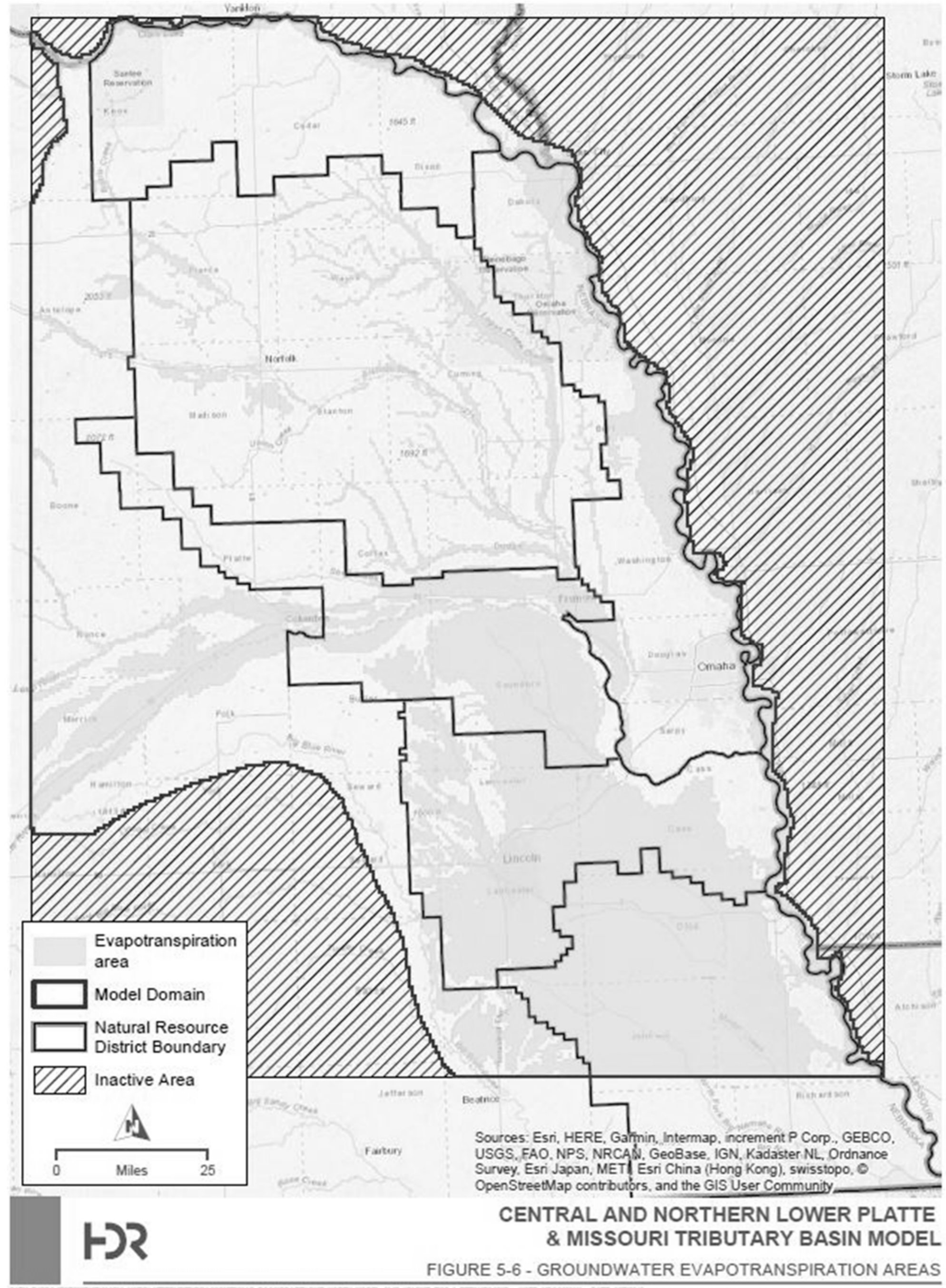
Watershed Model Outputs - Recharge



Evapotranspiration

- Added to the model post-review
- EVT is represented in areas where the water table is near the surface
- Uniform extinction depth of 7 feet was used
- Maximum ET rate of 40 in/yr, which was reduced by the average dryland pasture ET to account for water being taken out by the watershed model

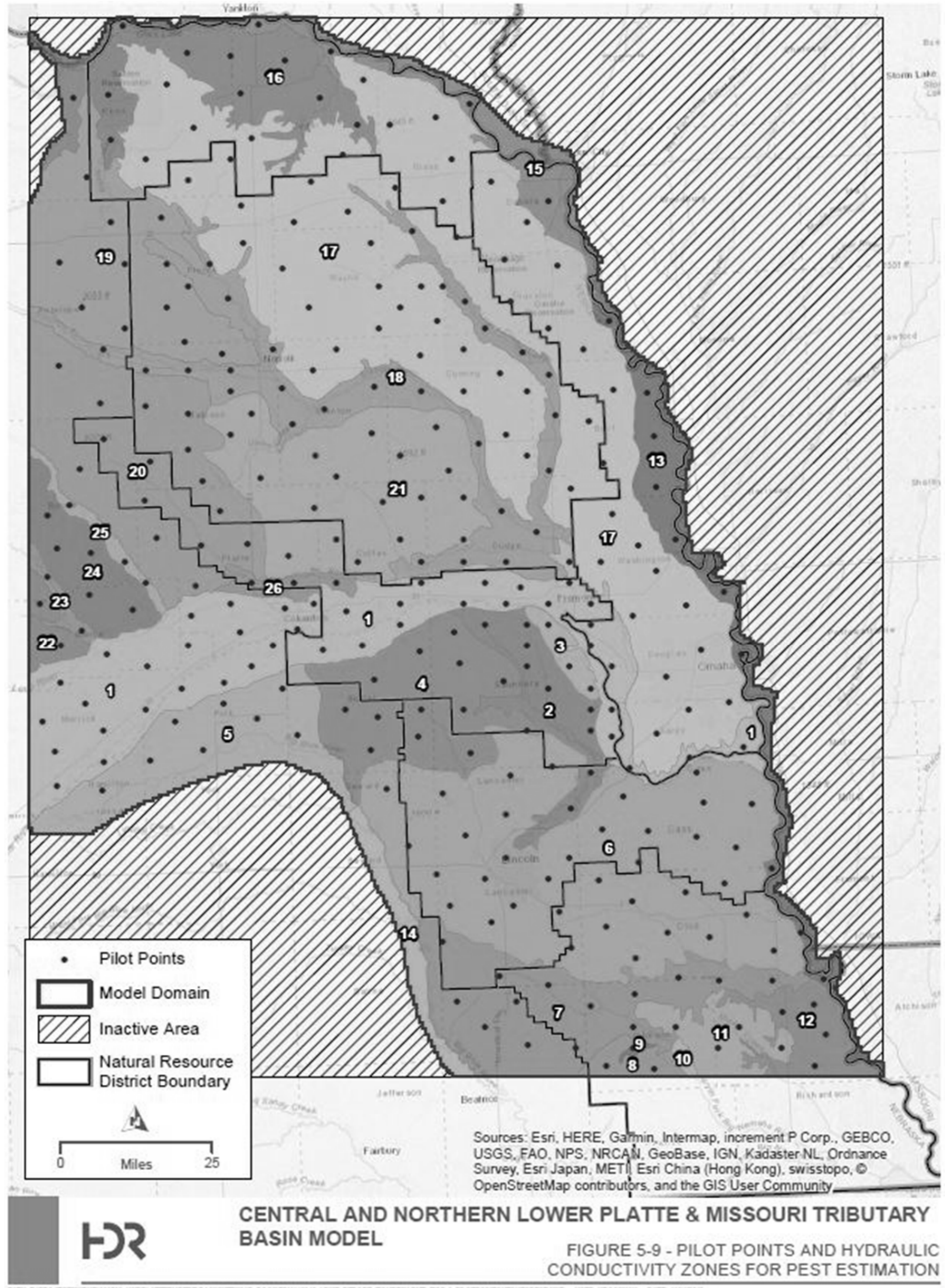
Evapotranspiration - EVT



Hydrogeologic Parameters

- Hydraulic Conductivity
  - Derived from inverse parameter estimation utilizing pilot points and K zones
  - Calculated with 26 conductivity zones and 309 pilot points
  - K Zones based on test-hole data, well data, aquifer absent areas, glacial till regions, and the 30 meter USGS DEM
- Storage
  - Layer 1 represented by unconfined specific yield term (0.15)
  - Layer 2 represented by a confined specific storage term (0.01)
- Leakance
  - Effective vertical hydraulic conductivity between the model layers
  - Calculated through inverse parameter estimation similar to hydraulic conductivity. Three zones were used

Hydraulic Conductivity



Hydraulic Conductivity

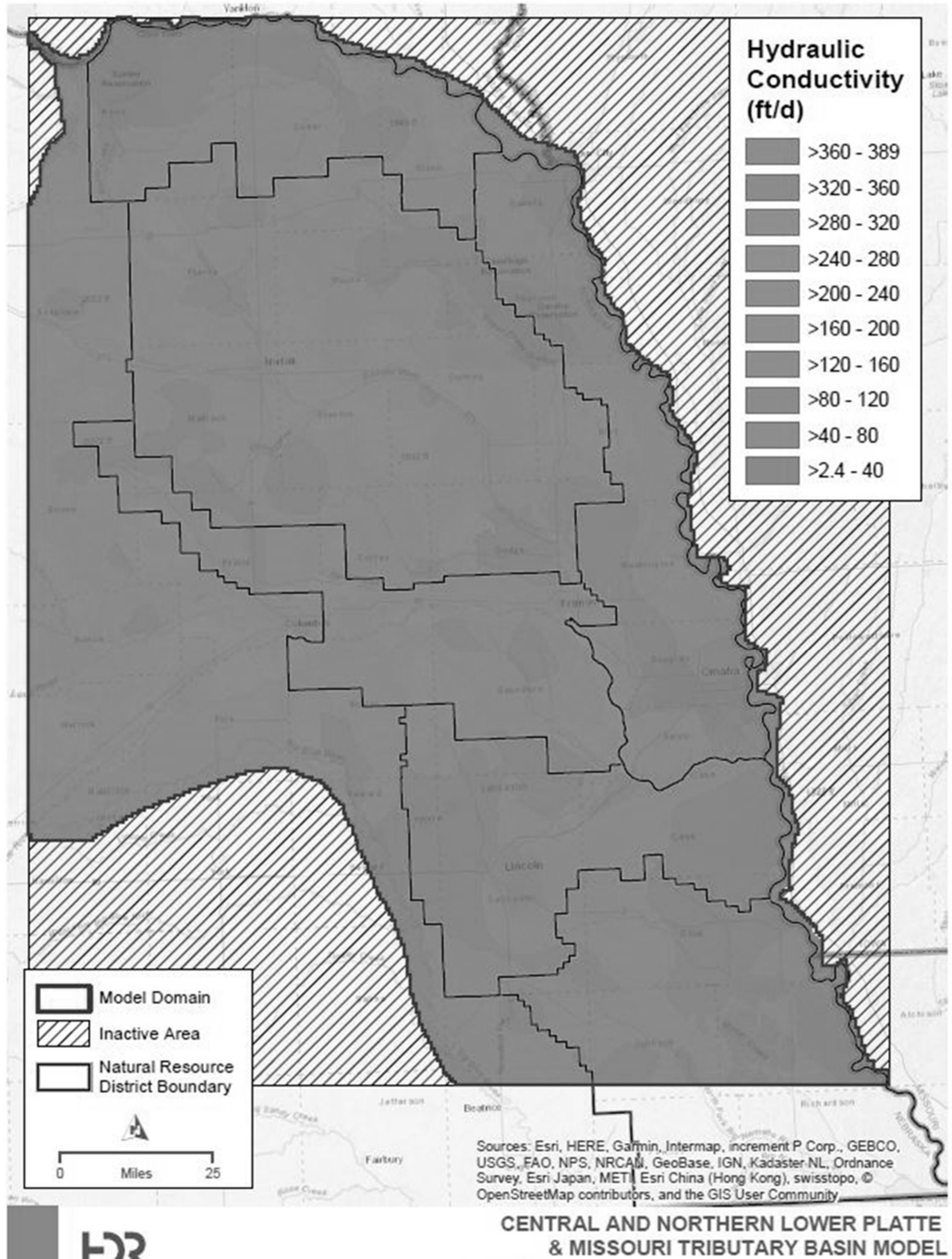


FIGURE 6-13 - CALIBRATED HYDRAULIC CONDUCTIVITY

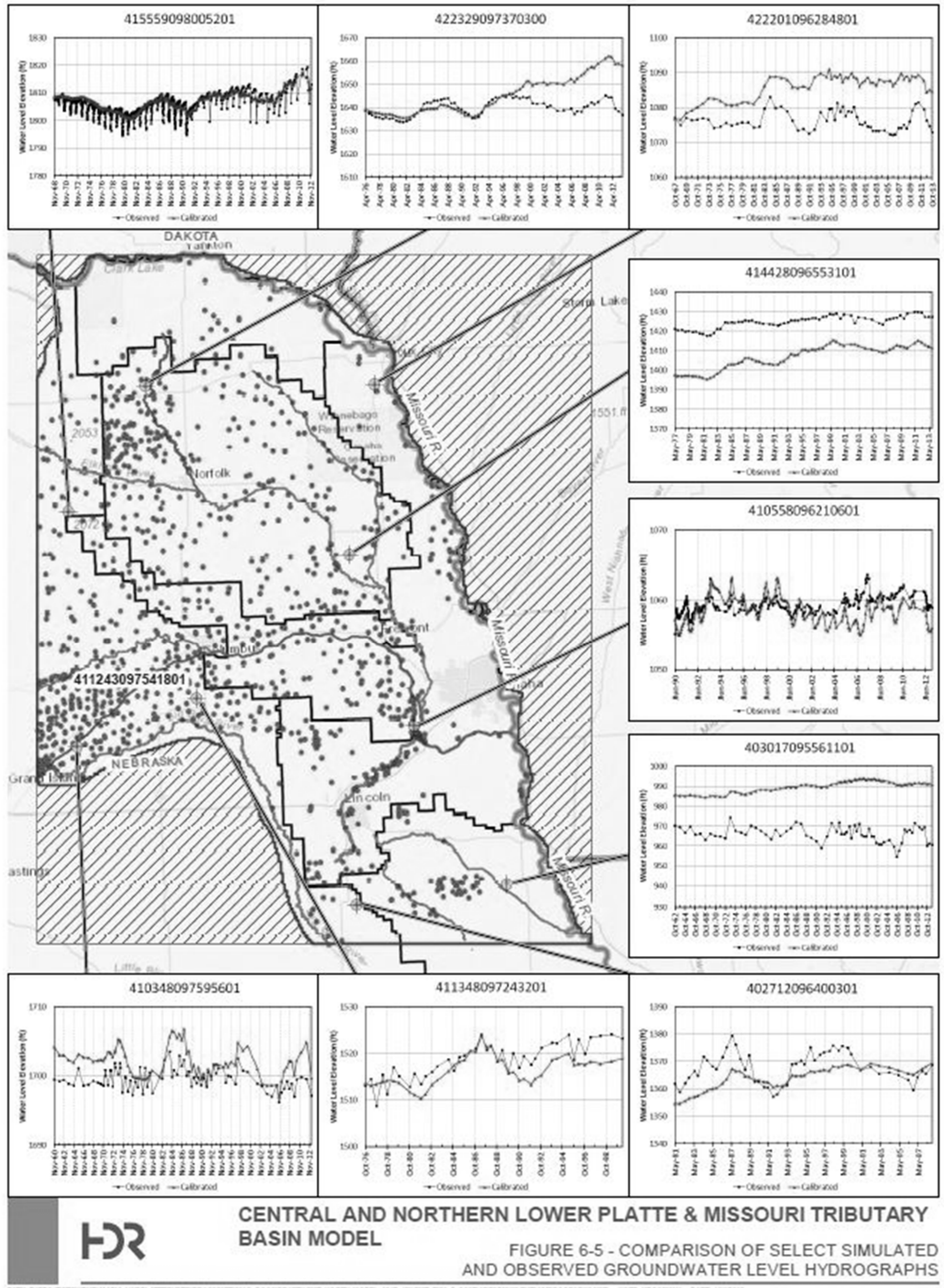
Calibration

- Calibration Targets
  - Groundwater Levels
  - Stream Baseflow
  - Synoptic Seepage
- Calibration Parameters
  - Recharge
  - Hydraulic Conductivity
  - Storage
  - Leakance
- Water Budget

Groundwater Levels

- Set of 1080 wells containing 83,575 measurements were used to represent the calibration period
  - Only wells spanning at least 10 years worth of data and 10 measurements during the calibration period were used
  - June, July, and August measurements were removed to limit impact from pumping
  - Only one monitoring well per cell was used to limit bias
- 2010 potentiometric surface was used as a target

Groundwater Levels



Stream Baseflow

- 40 streamflow gaging stations were chosen as calibration targets
- Baseflow separation was conducted on the daily total streamflow hydrographs as the groundwater model can only simulate baseflow
- The reach gains of the streams throughout the model helped in understanding how baseflow was being generated by the model

Stream Baseflow

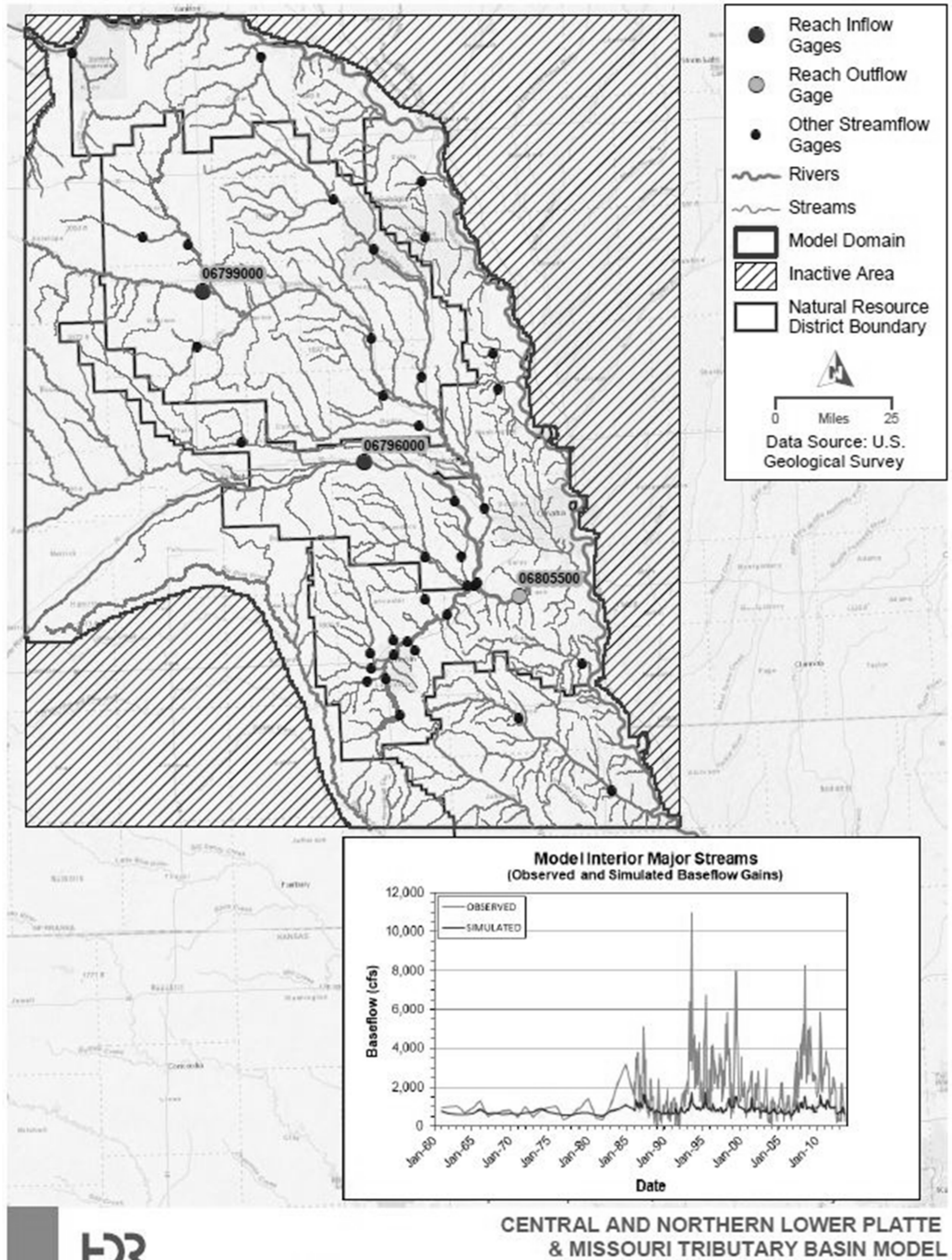


FIGURE 6-12 - SIMULATED AND OBSERVED INTERIOR REACH BASEFLOW GAINS

Synoptic Seepage

- A survey of 90 known or suspected seepage locations was conducted by NeDNR in October 2014
  - Goal was to identify seepage areas
  - Used to see if the groundwater model could reproduce them
- 67 of the sites visited were noted as “wet”
  - Model was able to replicate 27
- Some of the suspected sites were dubious as there had been recent rainfall event prior to the site visit
  - Ponding
  - Overland flow

Synoptic Seepage

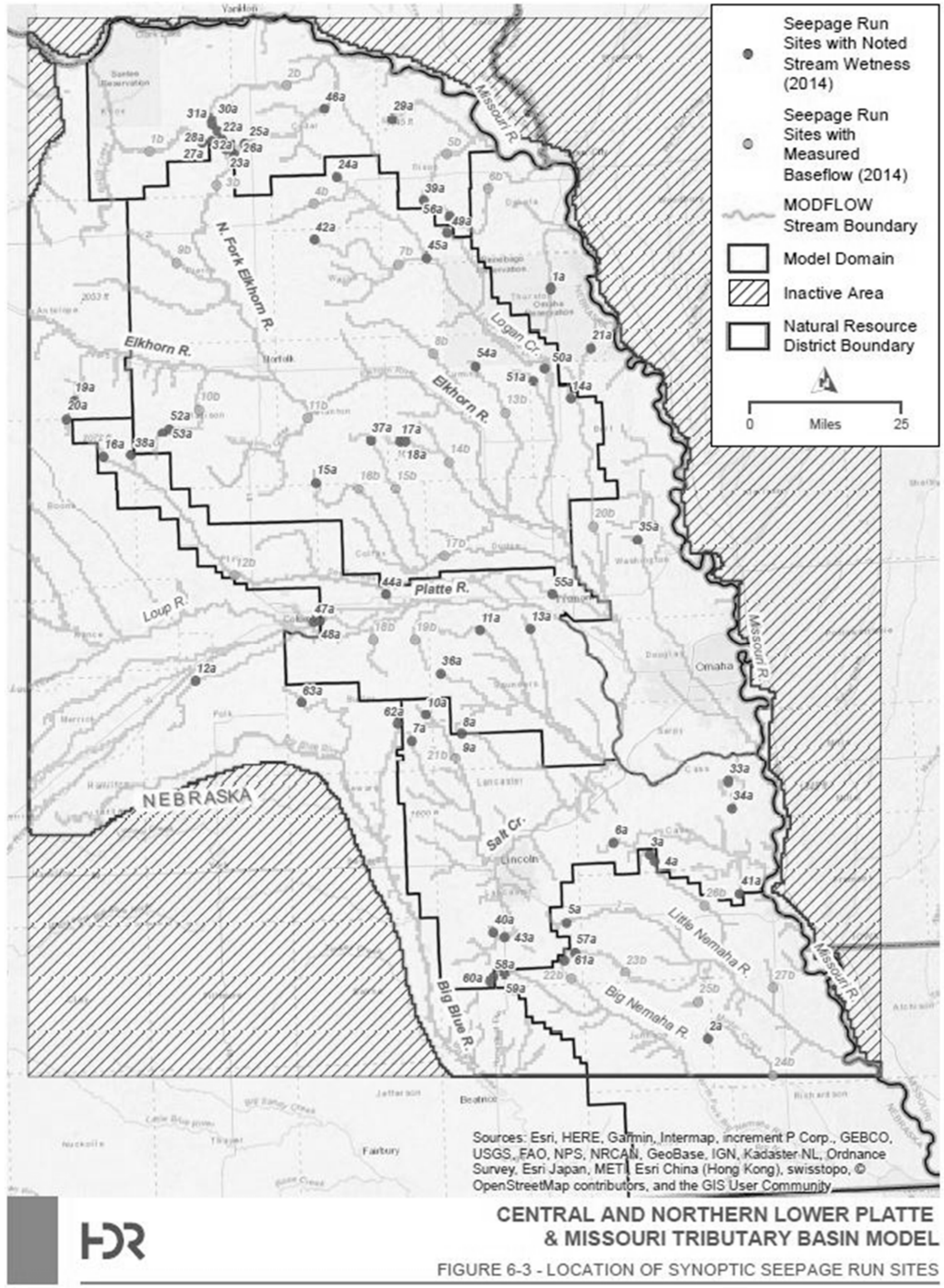


FIGURE 6-3 - LOCATION OF SYNOPTIC SEEPAGE RUN SITES

Water Budget

Table 6-4. Model Volumetric Water Budget for Steady-State Predevelopment Conditions

Component	In		Out		Net	
	ac-ft/yr	cfs	ac-ft/yr	cfs	ac-ft/yr	cfs
Storage	0	0	0	0	0	0
Wells	0	0	0	0	0	0
River Leakage	266,168	368	561,448	776	-295,280	-408
Stream Leakage	487,706	674	1,753,792	2,422	-1,266,086	-1,749
ET	0	0	522,573	722	-522,573	-722
GHB	373,752	516	43,548	60	330,204	456
Recharge	1,711,653	2,364	0	0	1,711,653	2,364
Total	2,839,279	3,922	2,881,361	3,980	-42,081	-58

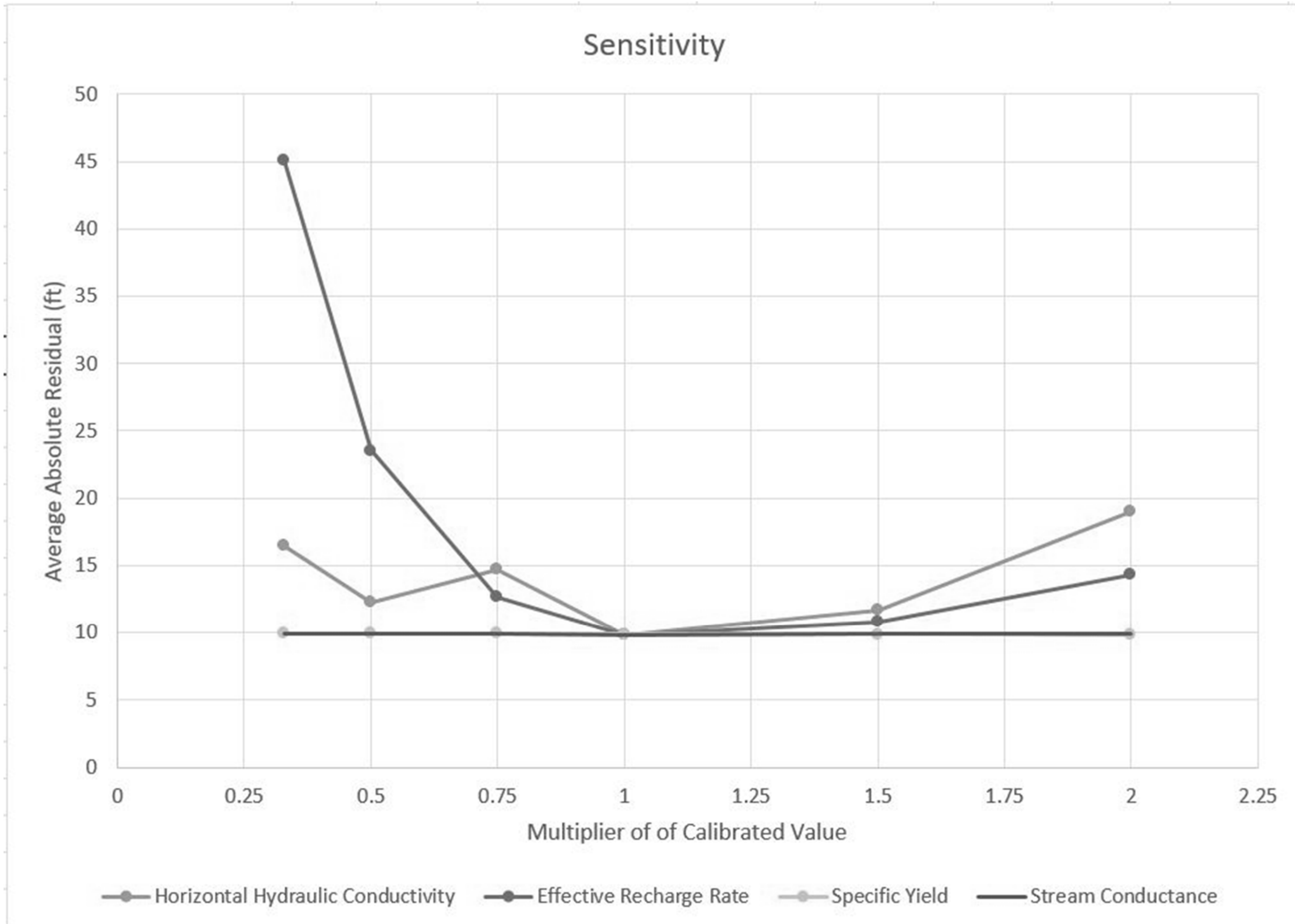
Notes:
ac-ft/yr = acre-feet per year, cfs = cubic feet per second, ET = evapotranspiration, GHB = General Head Boundary

Table 6-5. Average Model Volumetric Water Budget for the 54-year Calibration Period

Component	In		Out		Net	
	ac-ft/yr	cfs	ac-ft/yr	cfs	ac-ft/yr	cfs
Storage	1,477,268	2,041	1,653,910	2,285	-176,642	-244
Wells	0	0	909,663	1,256	-909,663	-1,256
River Leakage	270,323	373	621,823	859	-351,500	-486
Stream Leakage	571,671	790	2,113,926	2,920	-1,542,256	-2,130
ET	0	0	592,528	818	-592,528	-818
GHB	382,508	528	63,798	88	318,710	440
Recharge	3,249,745	4,489	0	0	3,249,745	4,489
Total	5,951,514	8,221	5,955,649	8,226	-4,135	-6

Notes:
ac-ft/yr = acre-feet per year, cfs = cubic feet per second, ET = evapotranspiration, GHB = General Head Boundary

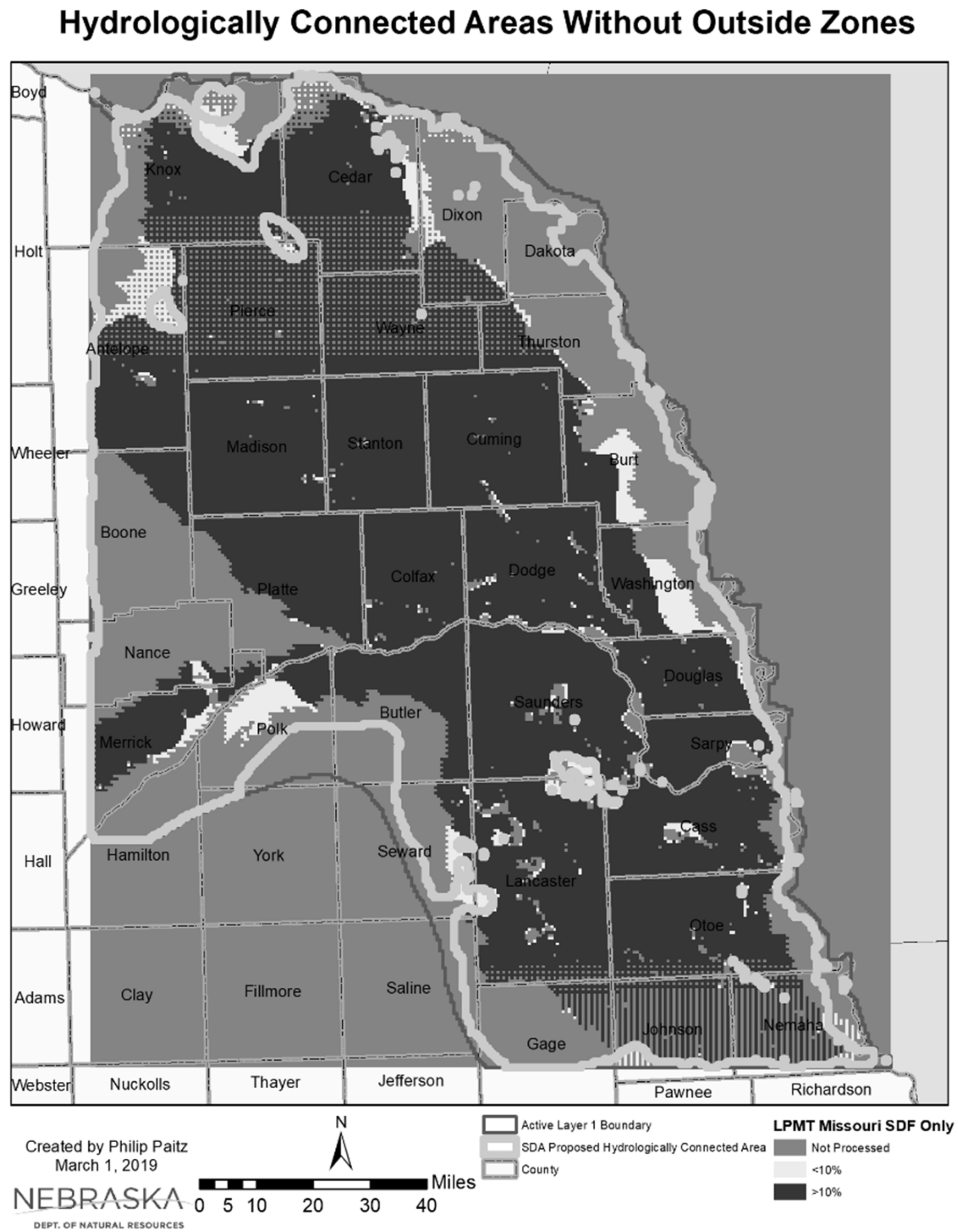
Sensitivity Analysis



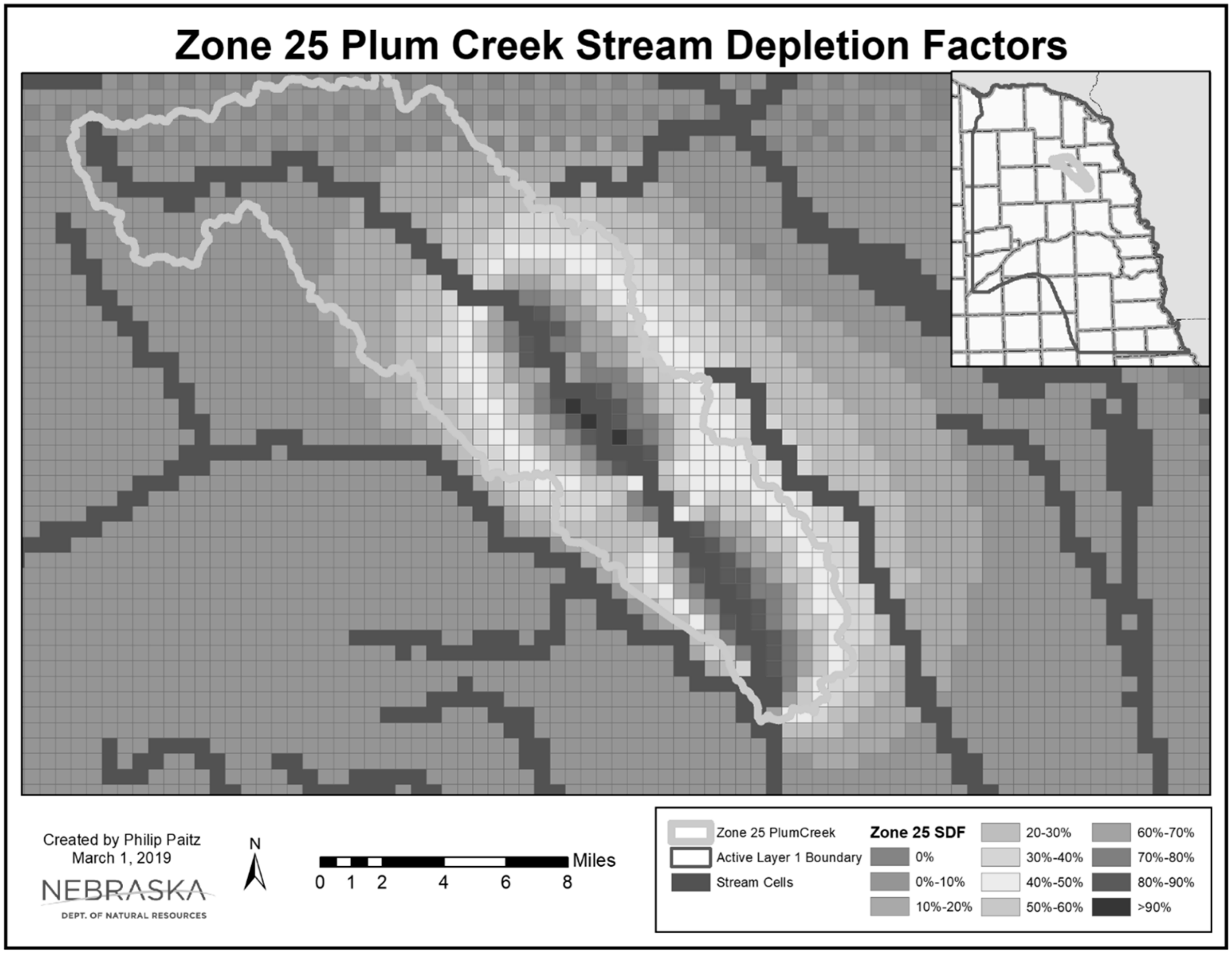
The LPMT Model in Use

- The Lower Platte Missouri Tributaries Model is now being used within the department to determine the hydrologically connected areas within the region
- Currently being incorporated into SUSTAIN and the CIR calculator
- In partnership with the NRDs, there are currently two pilot projects underway
  - Examine and incorporate AEM data into the LPMT Model
  - Develop local sub-models

LPMT Cycle Well Results 1 Missouri Tributary Zones



LPMT Cycle Well Results 2
Single Tributary Zone



Summary

- LPMT Model was constructed to aid in the study of impact to streams within the region with an emphasis on hydrologic connectivity
- Utilizes a Watershed model to simulate pumping and recharge
- Model was calibrated to three targets
  - Groundwater Levels
  - Stream Baseflow
  - Synoptic Seepage
- Process is underway to determine the hydrologically connected areas within the model

Where Can I Get the LPMT Model?

- https://dnr.nebraska.gov/Lower-Platte-Missouri-Tributaries-Groundwater-Model

Data and Documentation

- Final Report: Lower Platte / Missouri Tributaries Groundwater Flow Model (November 2018)
  - Appendices
    - Appendix A: Work Plan for Final Modifications to the Groundwater Model
    - Appendix B: Watershed Model Documentation
    - Appendix C: Groundwater Level Hydrographs
    - Appendix D: Baseflow Hydrographs
  - Model Files
    - Lower Platte/Missouri Tributaries Groundwater Flow Model Files
    - Lower Platte/Missouri Tributaries Watershed Model Files
- Groundwater Model Development Plan for the Lower Platte and Missouri River Tributary Basins (HDR, 2014)
- Hydrogeologic Assessment for Potential Development of Groundwater Modeling Tools in the Lower Platte River and Missouri River Tributary Basins (HDR, 2013)
- Analysis of Available Hydrogeologic Data and Conceptual Model of the Hydrogeology wihtin the Lower Platte River and Missouri River Tributary Basins (HDR, 2012)

THANK YOU

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SUSTAIN and the Lower Platte Missouri Tributaries Model

NRD Spring Water Conference

March 4, 2019

Margeaux Carter

Water Planning IWM Specialist

SUSTAIN: A Water Management Tool

Software tool developed by NeDNR for NRDs and water managers

- Improve access to
  - Regional historical water use data
  - NeDNR's hydrologic model outputs
- Increase transparency of NeDNR's
  - Hydrologic modeling process
  - Water management project evaluation methods
- Increase understanding of
  - Changing water use patterns
  - Impacts of water use on regional hydrologic systems

SUSTAIN: A Water Management Tool

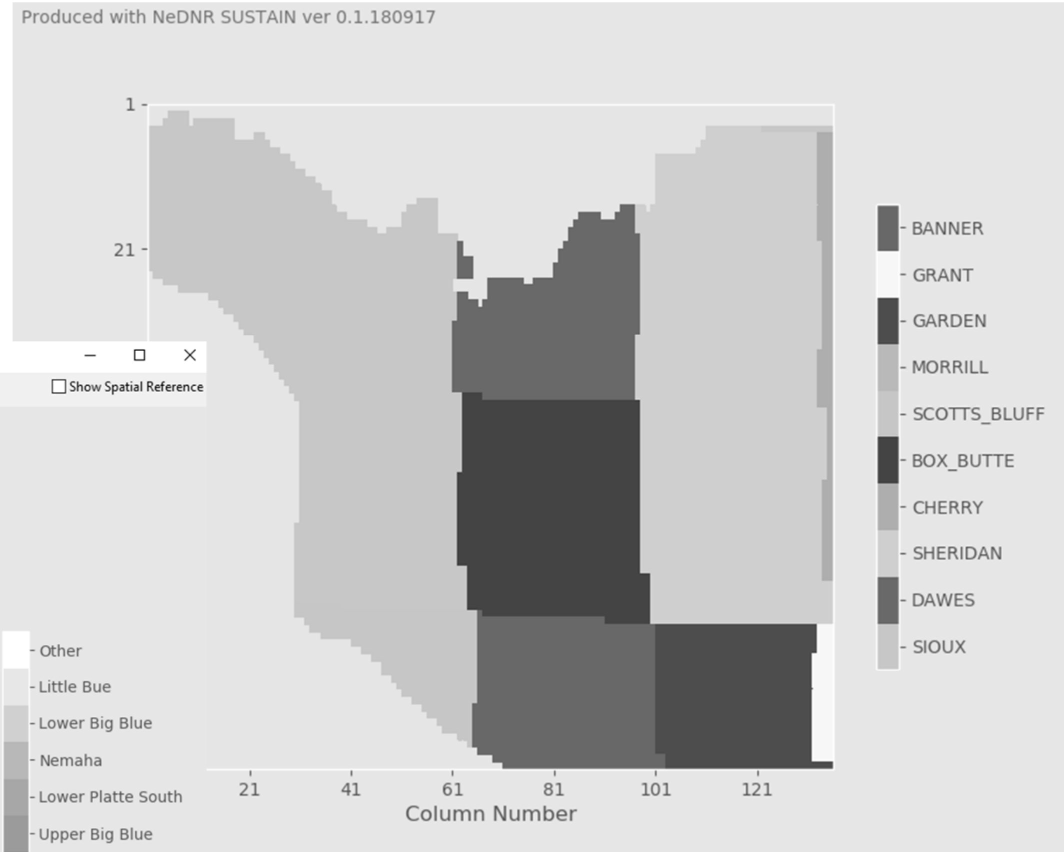
A graphical user interface which allows NRDs to:

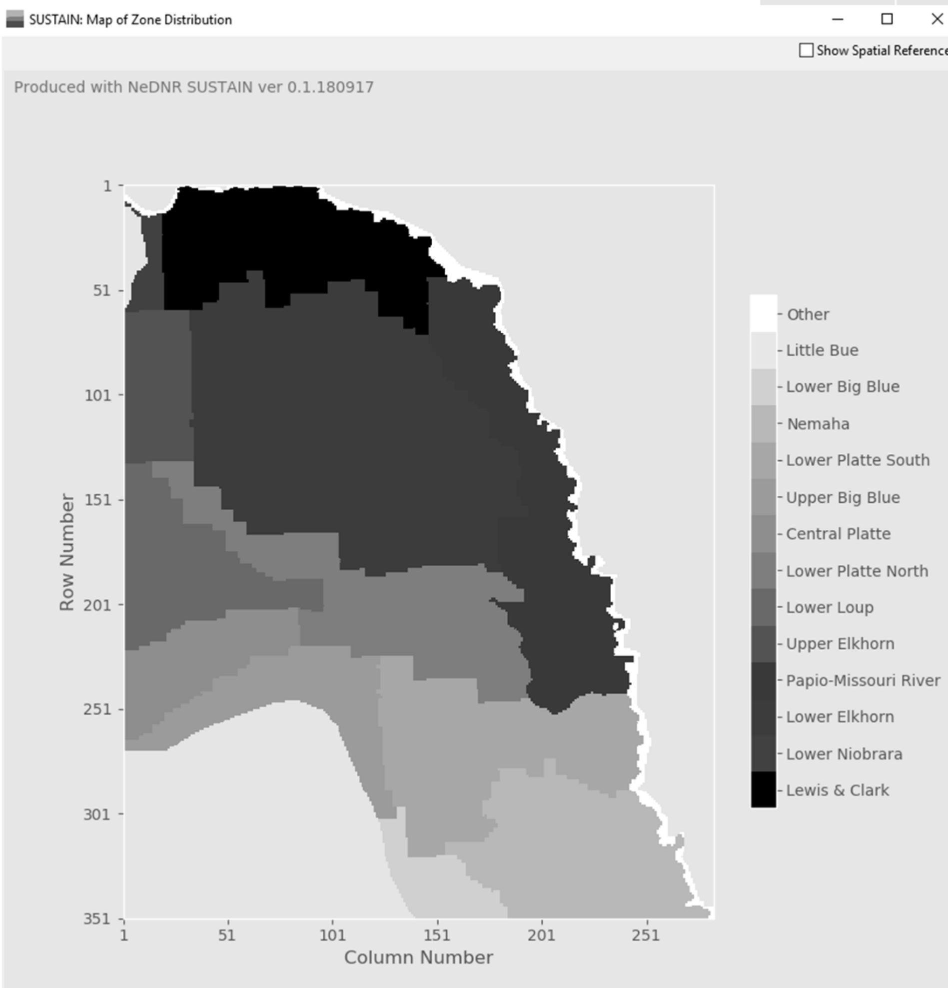
- Access NeDNR data
- View groundwater model inputs
- Evaluate water management scenarios
- Run NeDNR groundwater models
- Customize graphs
- Export data

SUSTAIN: A Water Management Tool

- Access water use data
  - model-wide data
    - UNW and LPMT models
    - 1960 - 2010
    - Includes water use reporting meter data
  - easily process and display data for education/outreach
  - export data for more options
- Evaluate water management projects
  - Estimate likely to be similar NeDNR's official evaluation
  - Good for tuning project proposal
  - NeDNR support in development

LPMT Model





UNW Model