NPNRD Stakeholder Meeting #2 Minutes

Project: Stakeholder Advisory Committee Meeting to Jointly Develop 2nd Increment Integrated Management Plan (IMP) with North Platte NRD (NPNRD) and Nebraska Department of Natural Resources (NeDNR)

Subject: Stakeholder Meeting #2

Date: Thursday, August 16, 2018, from 2:00 p.m. – 4:00 p.m.

Location: North Platte Natural Resources District office, 100547 Airport Road, Scottsbluff, Nebraska

I. Welcome

a. This is an Open Meeting

a. Meeting was opened at 2:00 p.m. MDT by Stephanie White, Facilitator, HDR Inc. A copy of the open meetings act was in the room and notice of the meeting was published in the Scottsbluff Star Herald (Attachment A).

- i. Discussion of agenda (Attachment B), and safety procedures including discussion of the eight (8) NRD planning survey responses from the group.
- ii. Agendas are posted prior to meeting on NeDNR website

b. Opening remarks were given by John Berge.

- i. September 8, NPNRD will be hosting their first Water Expo where they will provide classroom training and seminars on water technology. It will be a family-friendly event from 8 a.m.—4 p.m.
- ii. Staff Introduction and Introduction of all persons (stakeholders) present.

II. Administration

a. June Meeting Recap

b. Decision Making process

- i. Stephanie reviewed the of Roles and Responsibilities for NeDNR, NRDs, Stakeholders, and Joint NeDNR and DNR roles in relation to Basin Wide Plan and IMP.
  1. Majority Vote is all that is required to adopt plan components, although group consensus is preferred
  2. Board and NeDNR adopts and approves
- ii. The of future management goals need to be discussed and decided as the basin-wide plan will impact the District's plan.
- iii. Copies of presentations were handed out and are attached to these minutes (Attachment D).

III. Robust Review Results presented by Jennifer Schellpeper

a. The robust review is called for in the current IMP's monitoring section and its purpose is to assess progress made towards meeting the goals and objective of the first increment IMP as well as to provide data to inform management actions in the second increment.

b. Some assumptions were made for consistency and accommodation of data which include:

- i. Period of record modeled: 1953 to 2013;
- ii. Metered well pumping data used and repeated into the future;
- iii. 1997 level of development meets statutory requirements and the Nebraska New Depletion Plan;
- iv. Comingled acres are held constant in each run so that results show impacts of groundwater only pumping on streamflow;
- v. Crop types are used to calculate consumptive use;

- Model Results include the effects of:
    - o Changes in groundwater only irrigated acres
    - o NRD allocations
    - o Conjunctive Management Projects

c. Graphs show positive accretions to streamflow over time. The model analysis shows that in the year We 2019 there is between 22-24 thousand acre-feet accretion (more baseflow in the stream) to the stream as compared to the 1997 condition, and in 2029, it goes up slightly to 24 to 26 thousand, and 25 to 27 thousand at the fifty-year mark.

d. Conjunctive management projects, diverting water into existing canals for groundwater recharge, show a positive effect.

e. The first step to reaching fully appropriated status is to maintain the 1997 level of depletions.

IV. Stakeholder Questions/ Comments Period in regards to first presentation

a. New acres added district wide since 1997 only until the moratorium went into effect in 2004.

b. It is unknown if there are fewer wells now then in 1997 but there were fewer active acres in 1997.

c. Questions in regards to charts and graphs in the presentation:

i. Climate data shows the graph line swinging up and down representing wetter and dryer years.

ii. Model results are for NPNRD although change pattern was similar to NPNRD and SPNRD.

iii. Corn remains the most grown crop, and alfalfa has declined over the years.

iv. Excess flows are based on two items; (1) State protected flows, which are the existing surface water appropriations, their needs must be met and (2) Target flows for the Platte River Recovery Implementation Program (PRRIP) downstream must be met. In 2011, in a year that had huge snow pack we anticipated flooding and excess flows were available to be diverted then.

v. Model shows accretions everywhere in the District. It can show total accretions/depletions to streamflow.

i. There would be more water in the stream available for diversion by a downstream user than if the full 1997 level of development continued. This is the point of the statutes, to provide water in the stream for surface water users.

ii. Breakdowns are not by stream reach but a zone budget is possible. Documentation of this is being kept and at some point it will be public

vi. Regarding evapotranspiration: The model shows where precipitation falls, but is not able to track from where the moisture came from.

d. The goal of the 1st increment was to reach 1997 levels, not be fully appropriated, therefore the target was to get to 7,000 acre-feet of accretions and the goal was exceeded. The goal of the 2nd and subsequent increments, per statute, are to be fully appropriated. Fully appropriated is yet to be defined or a number set to it.

V. Second Increment Topics

a. Regulation

i. Methods used by NPNRD to successfully reach current stream accretion status was discussed.

ii. Presentation on regulations and incentives. The model is working well and the NRD is proud of it. There is emphasis on data and data collection. The producers are functioning well under the restrictions. Allocations are beneficial towards reaching IMP Goals. URF or Unit Response Functions are used to allow the district to determine the time frame in which water will reach the stream or how much water will accrete once the incentive is made. The modeled consumptive use is compared to actual use. The information is then used to set new allocations.

b. A period of questions and comments were opened up to the floor.

i. The presentation on Models was discussed at length.
ii. The model is fairly set since there is a lot of datasets. It is based on rainfall and climate repetition over the last 5 years. Refinements have been made, but the model is data driven so no calibration is needed.
iii. The Unit Response Function is an application evaluation tool. The projects (retirements, Epic, Allocation buy down, cost share, ect) are looked at to see if they are close and then an individual analysis is made to determine if it is a good use of funds.
iv. In regards to a comment about depletions, the model accounts for effects of return of evapotranspiration downstream, the lake downstream and the large drainage area.
v. Stakeholders would like updates in regards to data development in the process such as Robust Review results, and what the Basin Wide Plan says. A reminder is that any new requests can take a month, so if there are data requests that are not feasible for this time frame, they can be written into the plan.

c. Discussion on Goals of the 2nd increment
   i. Goals are dependent on the definition of Fully Appropriated. That needs to be distributed across the basin and brought to this group. As a basin they want to maintain what is done as a minimum. Goals inside the district need to be discussed in regards to financial resources. Millions of dollars have been spent on incentives, which doesn't include conjunctive management projects. The forecast for funding is decreasing so the prior spending levels cannot be maintained.
   ii. The funding section from 1st increment should be carried over to the 2nd increment.
      1. There is a forecast of 20% cumulative cut for incentives for the next 2 years. Financial resources impact how things are done. How to raise funds can be decided locally or by the Legislature. If funding levels would stay the same as current, it is still undeterminable if that is adequate for current level of funding because the Fully Appropriated number has to be determined. The NRD has to maintain the authority for the levy but as of last year, the full amount of the 3 cent levy was not being used.
      2. There is Federal level involvement with PRRIP, but this is state level funding with NeDNR and NRDs, the two projects are running simultaneously but they have different reasons. Different stakeholders are present with different priorities in regards to the resources in general.
   iii. Stakeholders' next concern and topic was depletions. Stakeholder input is needed for regulations and options to be considered for addressing depletions.
      1. Definition of fully appropriated status is getting close with the next draft of the Basin Wide Plan although a number is not stated.
   iv. Discussion was opened up for comments and questions in regards to drought planning and planning for water short times. For now, defining water short and drought are similar due to their similarities in impact.
      1. Maintaining economic viability is an important factor in water short years. Stakeholders stated that there is a need to take advantage of Surplus water years. This has been addressed with contracts for surface water diverters to divert into canals. State protected flows must be recognized before other water can be stored.
      2. A suggestion to talk to the State of Wyoming and the U.S. Bureau of Reclamation in regards to Glendo Reservoir about possibly relaxing federal regulations. Considerations are the purpose of Glendo Reservoir; storage vs flood control.
   v. Stephanie asked the group about additional items not already talked about.

1. Concerns were voiced in regards to pivot conversions on surface water acres. These have a significant impact on small ditch users in addition to the tributaries, a 3rd party harm. An idea of creating another reservoir in Nebraska was brought up. This would allow upstream use in high flow years, store it the ground and allow it to recharge. There was mention of additional understanding of depletions and evapotranspiration. Stakeholders had a discussion on the possibility of moving water down to small canals and recharge the aquifer via water not used for irrigation

vi. Stephanie asked the group about priorities for what they wanted to include in the 2nd increment. The topics discussed so far were additional understanding of depletions; Storage in many variations; including underground storage to counter the on-farm efficiencies; such as conversion to pivots. Any changes to statutes would have to go through the Legislature but that can be written into the IMP to "explore regulatory changes".

d. Partnerships with downstream partners was discussed to allow upstream users to hold water upstream instead of storing it downstream. Excess flows and recharge diversions are not covered by the IMP.

e. Financial constraints and requirements downstream are the largest obstacles for the future. Constraints could be worked out through partnerships with downstream users, and their demands for those waters. This is no different than trading with PRRIP. However, the cost of new storage is a reality that should be understood. We can look into partnerships upstream as well. We've had success utilizing underground storage, and repeating what has been done.

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g. Stephanie asked each stakeholder to indicate what two topics they want to talk about at the next meeting. Results of that discussion; items 1 through 6, which are ranked most popular to least; items 7-13 are equally ranked, are as follows

1. What is the water goal beyond meeting 1997 levels? +11
2. Planning for water short years; Drought planning +8
3. Provisions for upstream use + 7
4. On farm efficiencies-pivot conversion on sw acres +5
5. Maintain economic viability +1
6. Maintaining the integrity of surface water rights +1
7. Continued understanding of depletions, an "in district" issue
8. Municipal efficiencies (2026)
9. Storage:
    a. Requirements downstream
    b. Permitting and money
    c. Utilize underground storage
    d. Repeat 2016 process
    e. Improve infrastructure $$
    f. Upstream use
10. Trading with PRRIP-Pathfinder
11. Excess flow diversions and recharge
12. Obstacles aren't within the IMP
13. Partnerships w/downstream users/demand

VI. **Conjunctive Management**

a. Stephanie outlined the topics for next meeting, encouraged the group to self-educate and to think about conjunctive management which will be discussed at the next meeting.
b. NeDNR will bring a glossary of terms handout to next meeting.

VII. **Public Comment**- (Member of the public attending the meeting) commented on the topics of interest relating a previous experience with conjunctive management. She indicated that rather than building a large reservoir, the water conservancy group went to individual operators and used small reservoirs for recharge. This worked very well, and was cost efficient. She encouraged the stakeholders to look to others' successes.

VIII. **Meeting adjourned:** 4:05 p.m.

IX. **Next Meeting:** November 15, 2018.

Attachments to Minutes:

Attachment A- Affidavit of Publication of Notice of Meeting
Attachment B- Agenda
Attachment C- Copy of attendance sheet
Attachment D- Copies of all presentations
Attachment E- Water Matters (two issues) on conjunctive management and (two issues) on stream depletions

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    e. Repeat 2016 process
    f. Improve infrastructure $$
    g. Upstream use
14. Trading with PRRIP-Pathfinder
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17. Partnerships w/downstream users/demand

X. Conjunctive Management

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XII. Meeting adjourned: 4:05 p.m.

XIII. Next Meeting: November 15, 2018.

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AFFIDAVIT OF PUBLICATION

Star Herald
PO Box 1709
Scottsbluff, NE 69363

State of Nebraska
County of Scotts Bluff } ss.

I, *Yolanda Blue* do solemnly swear that I am the Accounts Receivable Bookkeeper of the Star-Herald, a legal newspaper of general circulation, published daily except Mondays, at Scottsbluff, Scotts Bluff County, Nebraska; that the notice hereto attached and which forms a part of this affidavit was Published in said paper *1 (one)* consecutive week (s) in the issues published, respectively *August 7, 2018*

that said notice was published in the regular and entire issues and every number of the paper on the days mentioned, the same being the corresponding day of each week during the period of time of publication and that said notice was published in the newspaper proper and not in the supplement.

[signature]

SUBSCRIBED in my presence and sworn to before me on 8-7-18.

[signature: Eric N. Hoffman]
Notary Public

ERIC N. HOFFMAN
General Notary – State of Nebraska
My Commission Expires Dec 15, 2021

The publication fees amount to $ *38.94*

NORPNT-54015979

NOTICE OF STAKEHOLDER MEETING
MEETING RELATED TO THE NORTH PLATTE NATURAL RESOURCES DISTRICT AND THE NEBRASKA DEPARTMENT OF NATURAL RESOUCES INTEGRATED MANAGEMENT PLAN

The Department of Natural Resources (Department) and North Platte Natural Resources District (NPNRD), are preparing an update to the integrated management plan (IMP) for NPNRD.

Notice is hereby provided that a public meeting of the IMP's Stakeholder Advisory Committee will be held on **Thursday, August 16, 2018,** at the North Platte NRD office, 100547 Airport Rd, Scottsbluff NE 69361. An agenda for the meeting will be available for public inspection during normal business hours at the offices of NPNRD and the Department, and at the following website: www.dnr.nebraska.gov. Please refer to the websites and phone numbers listed below for further information.

This stakeholder meeting will begin at 2:00 p.m. and end at approximately 5:00 p.m., Mountain Time, on Thursday, August 16, 2018. A public comment period will be provided.

The current IMP for NPNRD was developed following the determination in 2004 by the Department that the entire District was fully appropriated, and a portion of the District was overappropriated. NPNRD's current IMP was adopted in 2009 and is effective through fall of 2019, at which time a second increment IMP must be drafted and ready for adoption. According to Nebraska Revised Statute §46-715, the IMP will be developed in consultation and collaboration with District stakeholders and include: clear goals and objectives with a purpose of sustaining a balance between water uses and supplies; a map of the area subject to the IMP; at least one groundwater control and one surface water control; and a monitoring plan.

Individuals with disabilities may request auxiliary aids and services necessary for participation by contacting PLANNER at the Nebraska Department of Natural Resources by 5 p.m. Central Time, Thursday, August 09, 2018 at 402-471-0661 or by email at beth.eckles@nebraska.gov.

NPNRD: http://www.npnrd.org or phone (308) 632-2749
100547 Airport Road, Scottsbluff, NE 69363

Department: http://www.dnr.nebraska.gov or phone (402) 471-2363
301 Centennial Mall South, 4th Floor, Lincoln, NE 68508

Published in the Star-Herald
1t, August 7, 2018

Agenda

Project:	2nd Increment Stakeholder Process for North Platte NRD Integrated Management Plan (IMP)
Subject:	Stakeholder Meeting #2
Date:	Thursday, August 16, 2018 from 2:00 p.m. – 4:00 p.m.
Location:	North Platte Natural Resources District Office 100547 Airport Road, Scottsbluff, NE

Agenda:

1. Welcome
2. Administration
   a. June meeting recap
   b. Decision making process
3. Robust Review Results
4. Second Increment Topics
   a. Regulation
   b. Conjunctive Management
5. Public Comment

Next Meeting: November 15, 2018

Attachment C - Copy of Attenance Sheet

Sign in Sheet

2ND Meeting – NPNRD IMP 2nd Increment Planning Process – August 16, 2018

NAME	ORGANIZATION REPRESENTED
Roger Eirich	NPNRD + Chimney Rock Irr.
Mike Drain	CNPPID
Robert Busch	Gering Ft Laramie surface water
Jeff Shafer	NPPD
Beth Eckles	NeDNR
Melissa Mosier	NeDNR
Shea Winkler	NeDNR
Alton Lerwick	
Joe Tros	
Steve Smith	NPNRD/NPVIA
Bruce Rolls	
Pat Heath	City of Gering
Skylar Loeffler	
Dennis Miller	
Jack Revelle	
Gary Lping	Minatare Mutual Canal President
Bryan Barrett	Farm Credit Services of America
Leo Hoehn	Hoehn Farms
Chuck Henkel	NPNRD
Dan Fisher	NPNRD
Michael Relka	Westernsugar
David W Howell	Howell Farms
John Berge	NPNRD

Attachment C - Copy of Attenance Sheet

Sign in Sheet

2[ND] Meeting – NPNRD IMP 2[nd] Increment Planning Process – August 16, 2018

NAME	ORGANIZATION REPRESENTED
Kyle Ann Hopkins	NPNRD
Scott Schaneman	NPNRD
Danielle J Schafer	NPNRD
Will Coggle	groundwater producer
Bill Halligan	SP NRD
Thad Kuntz	thad@ari-water.com
Jennifer Schellpeper	NeDNR
Barb Cross	NPNRD

NPNRD IMP

Meeting 2

NORTH PLATTE
Natural Resources District

NEBRASKA
DEPT. OF NATURAL RESOURCES

TODAY'S AGENDA

- Welcome
- Administration
  - June meeting recap
  - Decision making process
- Robust Review Results
- Second Increment Topics
  - Regulation
  - Conjunctive Management
- Public Comment

WELCOME

- Open meeting notice
- Safety & logistics
- Introductions

ADMINISTRATION

June meeting recap

Decision making process

ROBUST REVIEW RESULTS

2ND INCREMENT TOPICS

Regulation

Conjunctive Management

REGULATION

NORTH PLATTE
Natural Resources District

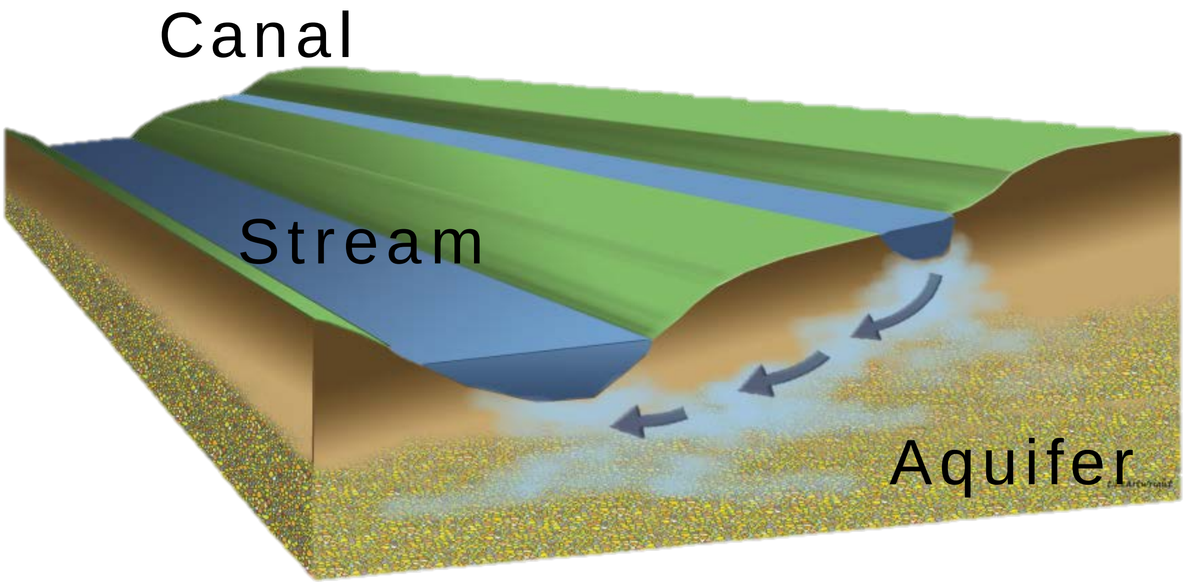
NEBRASKA
DEPT. OF NATURAL RESOURCES

CONJUNCTIVE MANAGEMENT

UNDERLYING CONCEPTS OF CONJUNCTIVE WATER MANAGEMENT

(CWM)

- Surface and groundwater resources are interconnected
- Decisions to improve the management of one cannot be made properly without considering the other



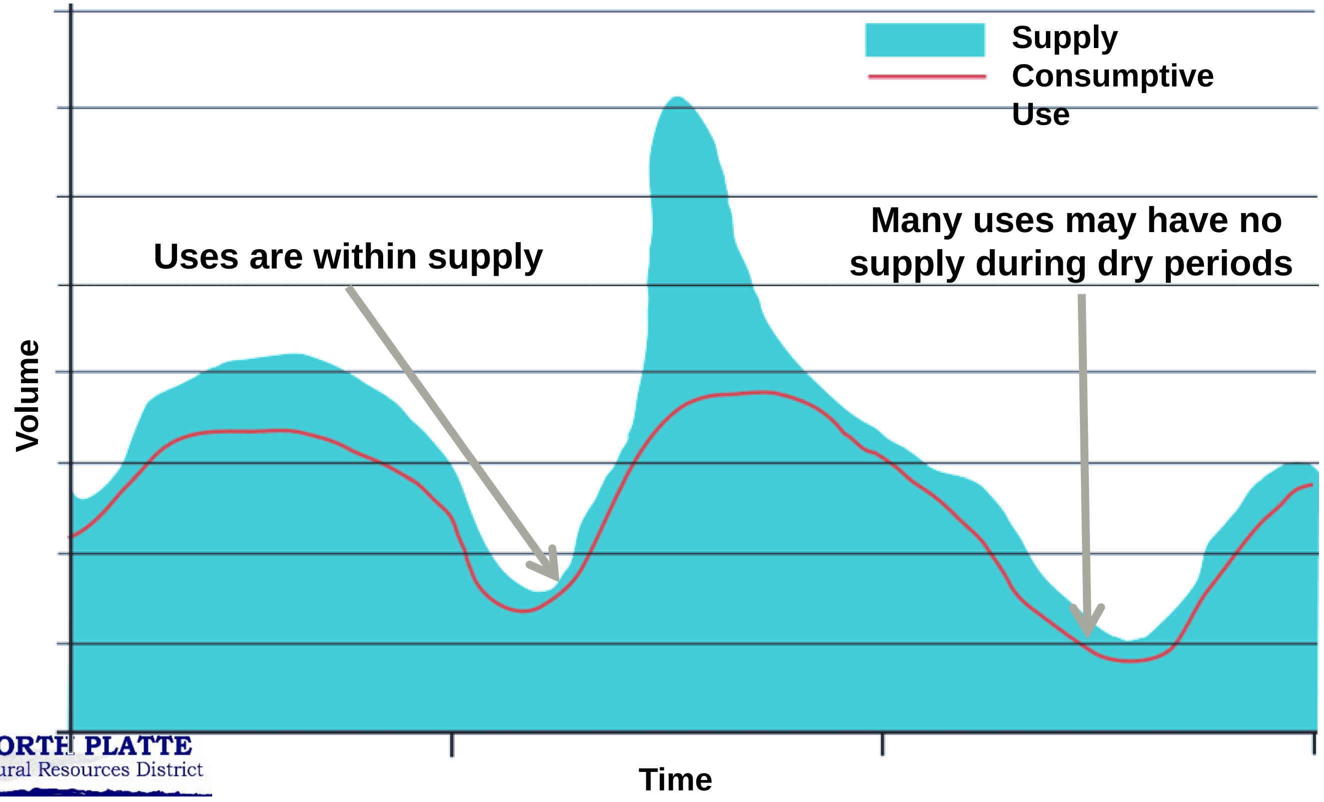
Conjunctive Water Management is an *adaptive process* that utilizes the *connection* between surface water and groundwater to *maximize water use*, while *minimizing impacts* to streamflow and groundwater levels in an effort to increase the overall water supply of a region and improve the reliability of that supply.

HOW IS CWM ACCOMPLISHED?

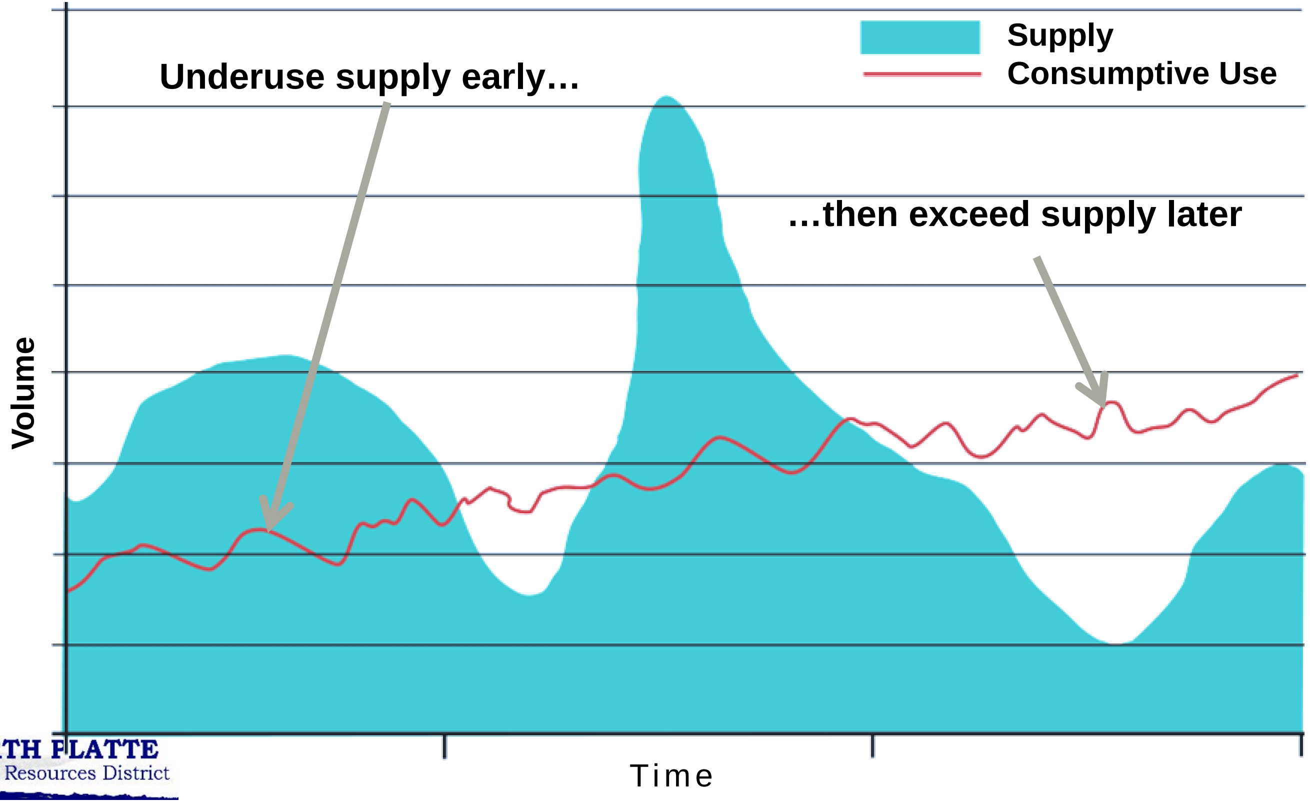
- Typically, by:
  - Using or storing additional surface water when it is plentiful
  - Relying more heavily on groundwater during dry periods

- Can change the timing and location of water for more efficient use

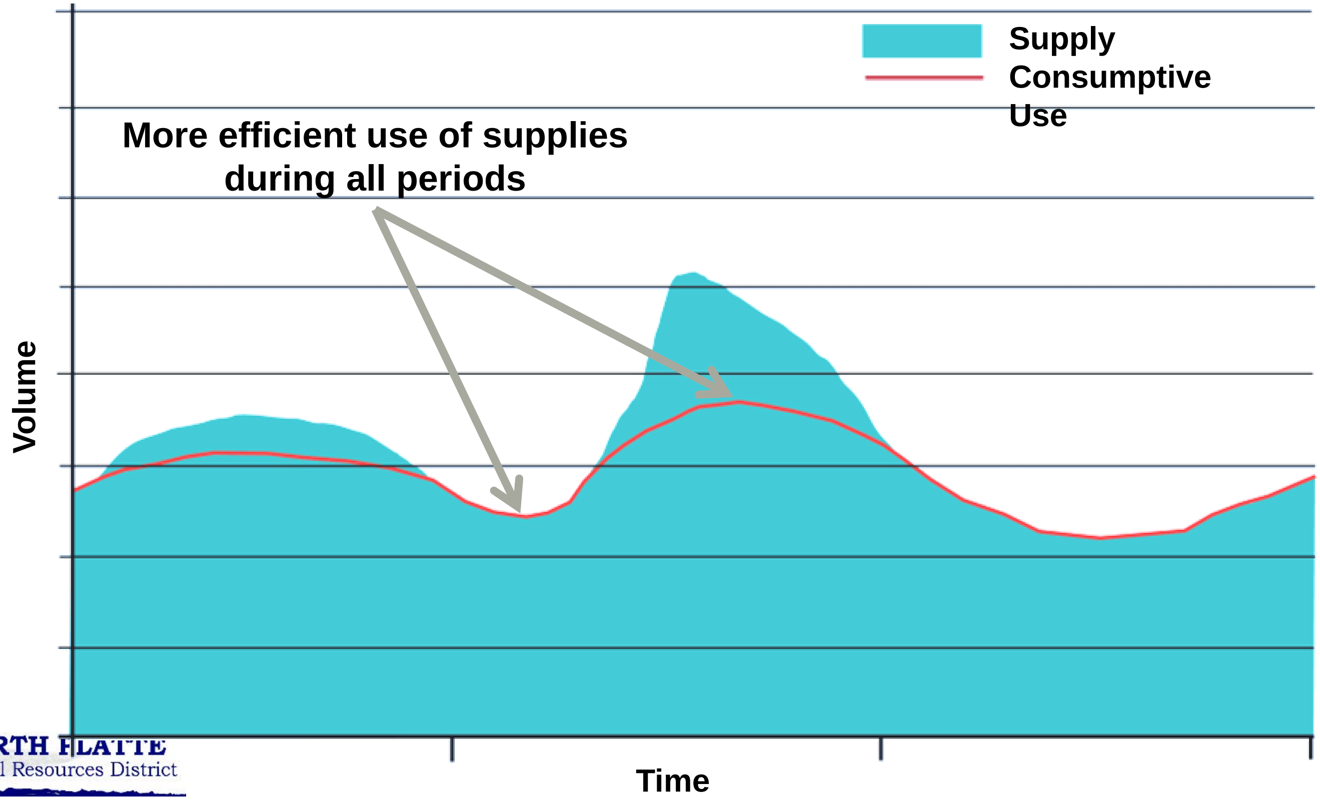
SCENARIO 1:
USING SURFACE WATER ONLY



SCENARIO 2:
USING GROUNDWATER ONLY



SCENARIO 3:
MANAGING SUPPLIES THROUGH CWM

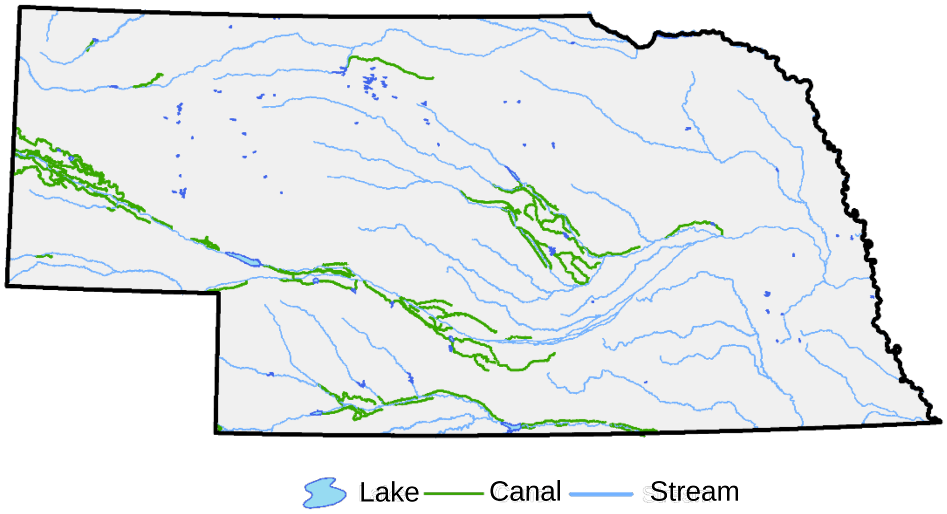


COMPONENTS OF CWM

- Surface water diversion and groundwater pumping
- Aquifer recharge
- Management of the timing of return flows
- Program for monitoring and evaluation

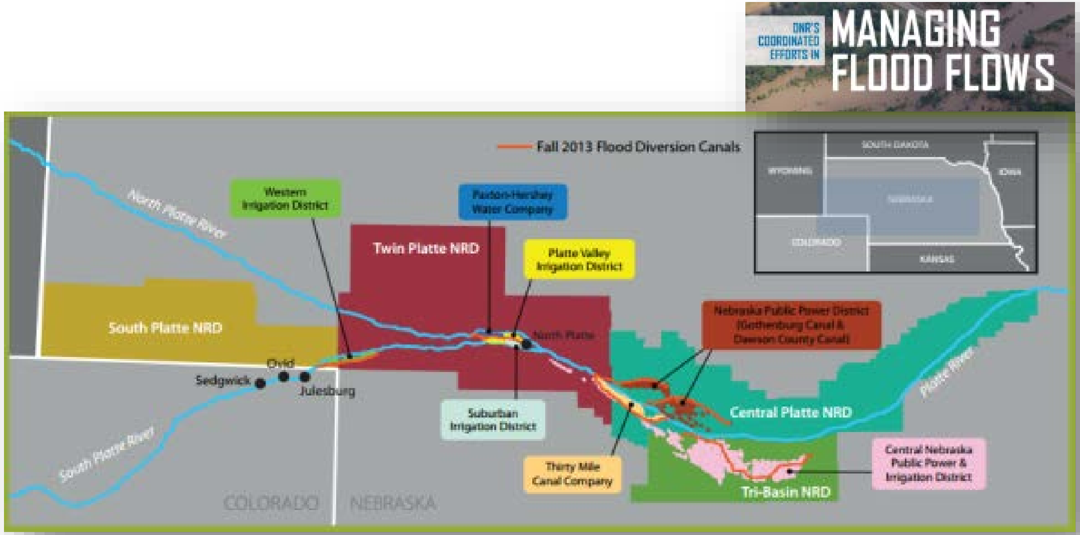
BENEFITS OF CWM

- Maximize available water supplies
- Leverage existing infrastructure
- Use existing planning framework
- Minimize the need for regulatory actions
- Customize to local opportunities or needs
- Maintain viability of existing uses



EXAMPLES OF CWM PROJECTS

- Augmentation projects
- Western canal conjunctive management study
- Water leasing arrangements
- CPNRD transfers and canal refurbishment
- Capturing excess flows using existing canal infrastructure (in partnership with irrigation districts)



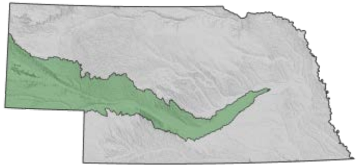
APPLYING CONJUNCTIVE MANAGEMENT

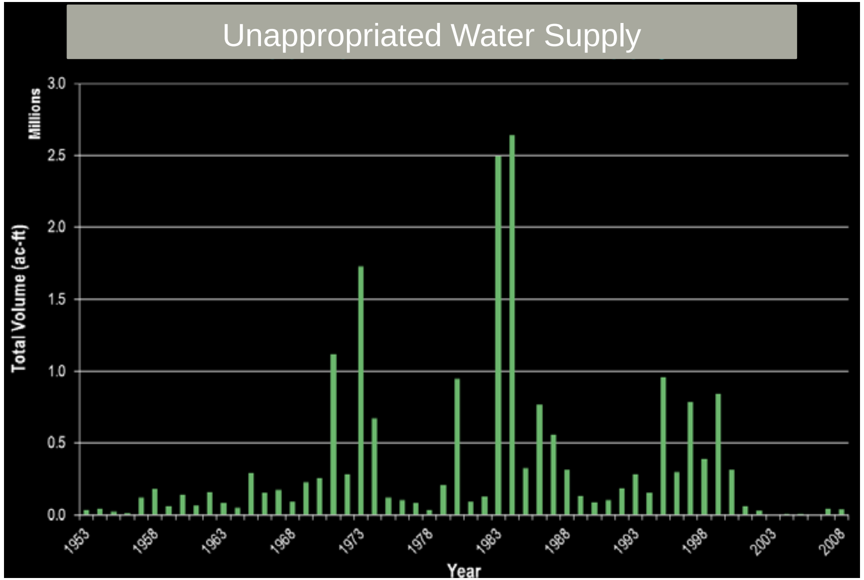
IN THE UPPER PLATTE RIVER BASIN

First Increment CWM Activities

UPPER PLATTE RIVER WATER SUPPLIES

- Receives average of 1 million ac-ft from snowmelt in Wyoming each year (North Platte Decree)
- More variable inflows in South Platte from Colorado
- Water is generally fully allocated, particularly above Elm Creek (overappropriated)
- Streamflows required to be shared under Endangered Species Act (Federal)
- Unappropriated water does occur during some very wet years, during shorter intervals, and outside of the irrigation season





2011 PILOT PROJECT

- High flows in spring prior to irrigation season
- NeDNR coordinated with NRDs, Irrigation Districts/Canal Companies to divert excesses
- Acquisition of permits
- Contracts
- Monitor

2011 PILOT PROJECT

- 23 Canals and 5 NRDs
  - Diversion Total 142,000 acre-ft.
  - Recharge Total 64,000 acre-ft.
  - 2011-2019 Returns 15,000 acre-ft.
  - NPNRD Diversion Total 61,260 acre-ft.
  - NPNRD Recharge Total 28,739 acre-ft.

2013 FLOOD FLOWS

Friday, September 20, 2013

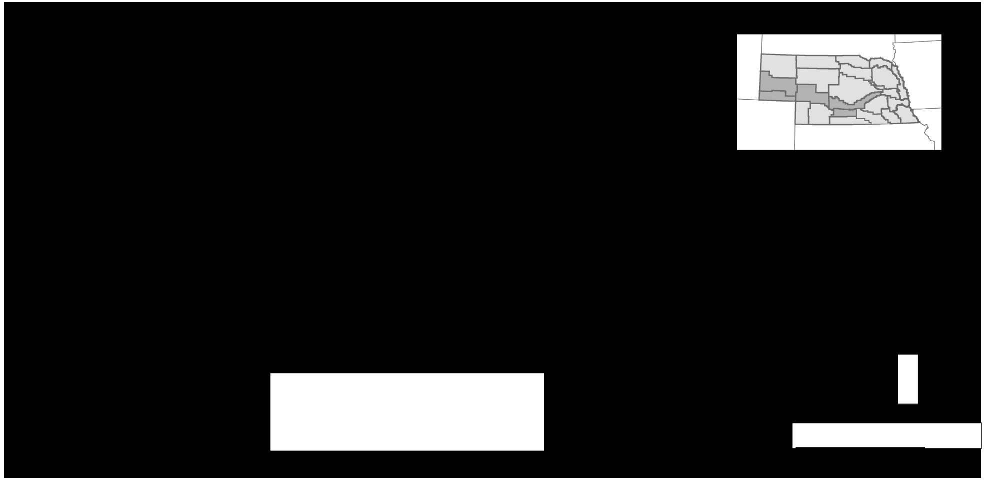
Saturday, September 21, 2013

South Platte River Highway 83 Bridge, North Platte, NE

South Platte River Buffalo Bill Road Bridge, North Platte, NE

2013 FLOOD FLOWS

- 9 Canals and 4 NRDs
  - Diversion Total 44,000 ac-ft.
  - Recharge Total 27,000 ac-ft.
  - 2011-2019 Returns 5,600 ac-ft.



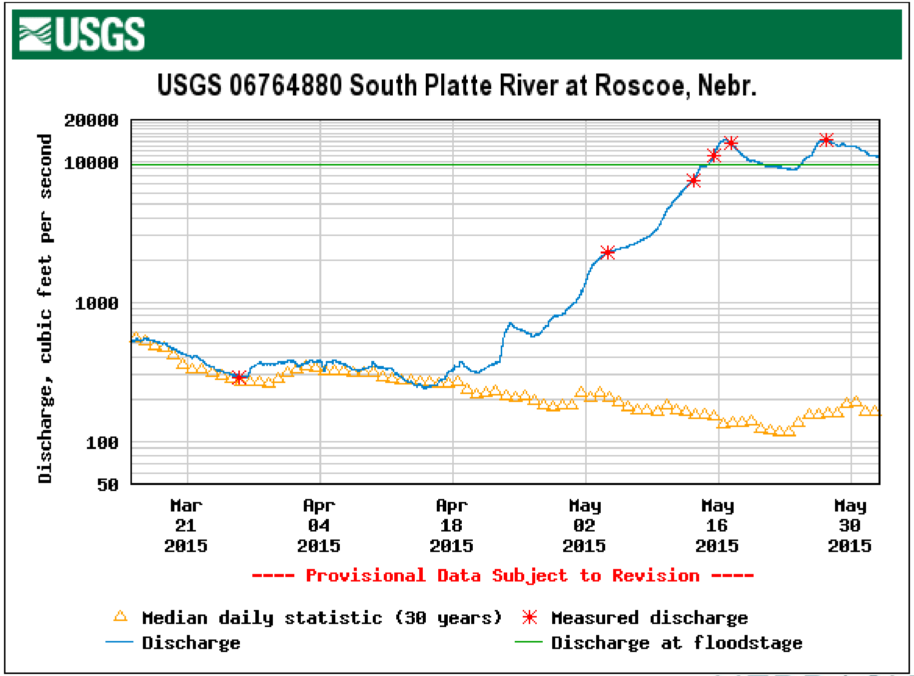
NORTH PLATTE Natural Resources District

NEBRASKA DEPT. OF NATURAL RESOURCES

2015 FLOOD FLOWS

- Wet conditions during above average spring snowmelt
- Canals filled early
- Stored excess in lakes, reservoirs

30-Mile Canal Headworks,
June 2015



2015 FLOOD FLOWS

- 7 Canals and 4 NRDs
  - Diversion Total 17,700 ac-ft.
  - Recharge Estimate 7,600 ac-ft.

NORTH PLATTE
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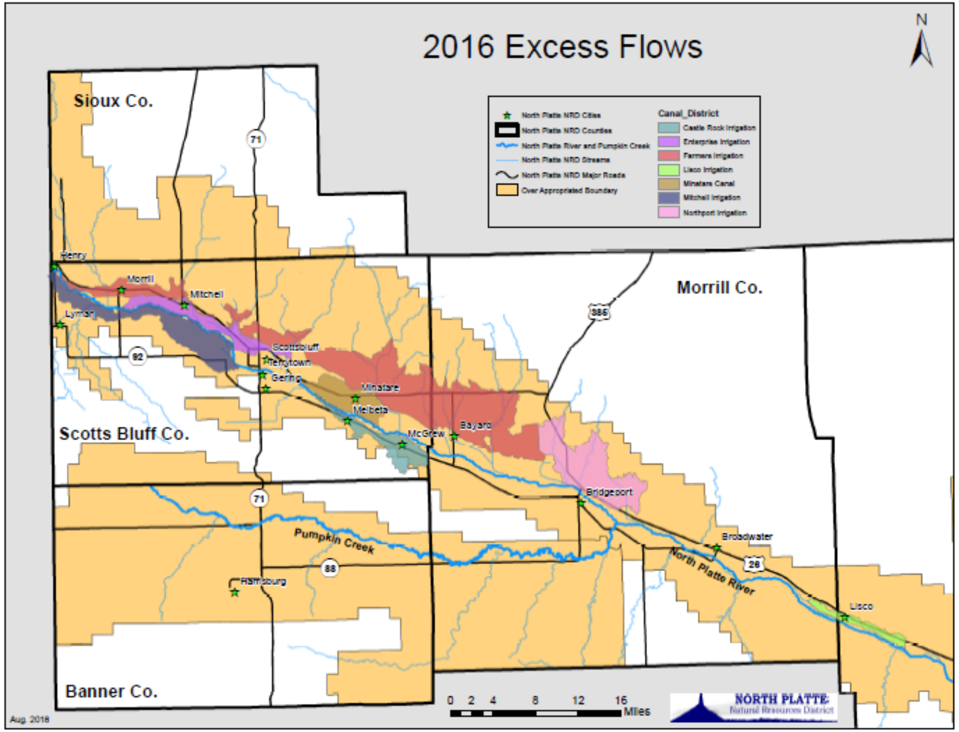
2016 FLOOD FLOWS

- 8 Irrigation Districts and Canal Companies
  - NPNRD Diversion Total

    30,369 ac-ft.
  - NPNRD Recharge Estimate

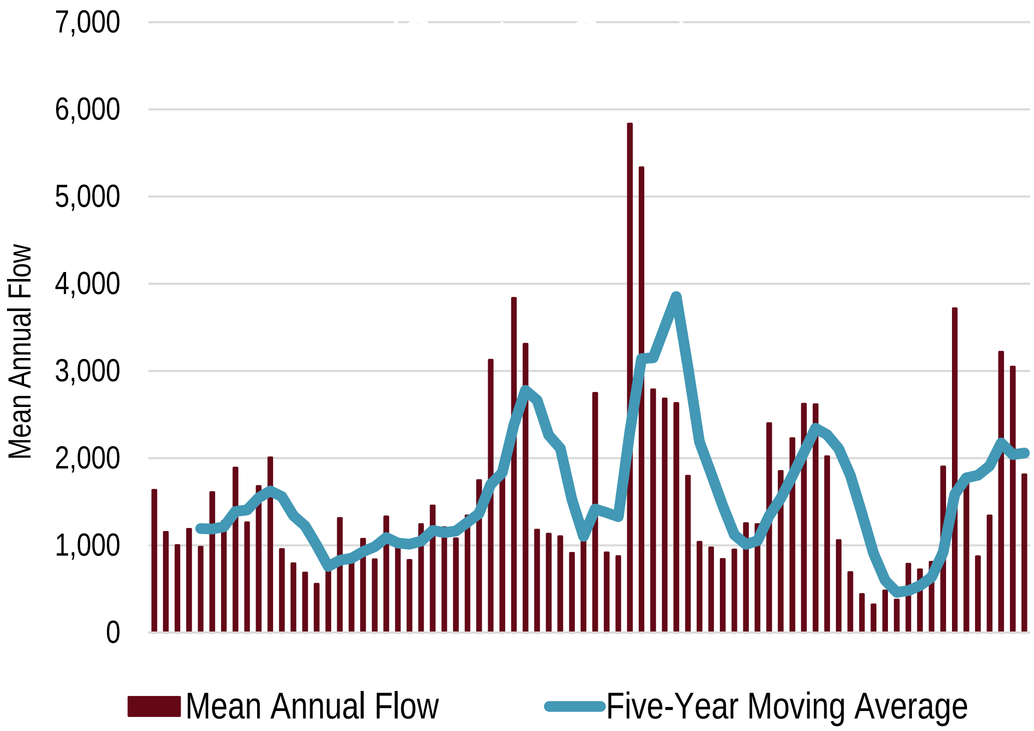
    13,812 ac-ft.



SUMMARY OF FLOOD FLOW DIVERSIONS

First Increment

- Over 200 Kaf of flood flows diverted since 2011
- Resulting recharge in excess of 100 Kaf
- Accretions will benefit Platte River flows for many years into the future
- Process in place for future successes
- Reduces the need for additional regulations
- Creates greater resiliency in future periods



NORTH PLATTE Natural Resources District

NEBRASKA DEPT. OF NATURAL RESOURCES

CWM FUTURE ACTIVITIES

- Expand implementation of CWM projects
- Enhance adaptation strategies based on management goals
- Support continued investment in maintaining and enhancing infrastructure
- Ensure that sound science and monitoring are available to support management decisions

Cozad Canal, Gothenberg, NE

CWM INFRASTRUCTURE EXAMPLES IN NPNRD

Schaneman Recharge Pits

- Have leased just over 100 acres on Enterprise Irrigation District
- Planning and will ultimately construct recharge pits to be used for surface water infiltration
- Project design has the capability of handling the entire diversion rate of the presently contracted acres, but will also allow for the construction of one or more recharge pits to allow for expansion

CWM INFRASTRUCTURE EXAMPLES IN NPNRD

Everett / Meyers Return

- Have leased four shares (320 acres) on Minatare Canal Company and have continued to divert water that would normally be delivered to those farms, but have built a direct return back to the river to gain consumptive use credit toward our goals and obligations under the IMP
- Designed with expansion in mind
- Project to date has returned back to the North Platte River 920 acre feet of water that would have otherwise been consumptively used by crops
- Annual operating cost of approximately $89,000.00 with 797 acre feet returned to the North Platte River in 2017
  - $112 per af

CWM INFRASTRUCTURE EXAMPLES IN NPNRD

Ducks Unlimited/NPNRD Recharge Project

- Actively searching for lands to temporarily lease the surface water appropriation from in order to divert that appropriation into man made recharge sites
- Those sites will not only benefit the recharging of the aquifer but will also provide needed habitat for migrating water flow
- Consumptive use credit from the temporary idling of crop acres to help NPNRD meet goals and obligations under the IMP

NEXT STEPS

MEETING DATES

- November 15, 2018
- January 17, 2019

PUBLIC COMMENT

Thank You

Robust Review Analysis

NPNRD Results

NPNRD IMP Stakeholder Meeting #2

August 16, 2018

Robust Review Goals

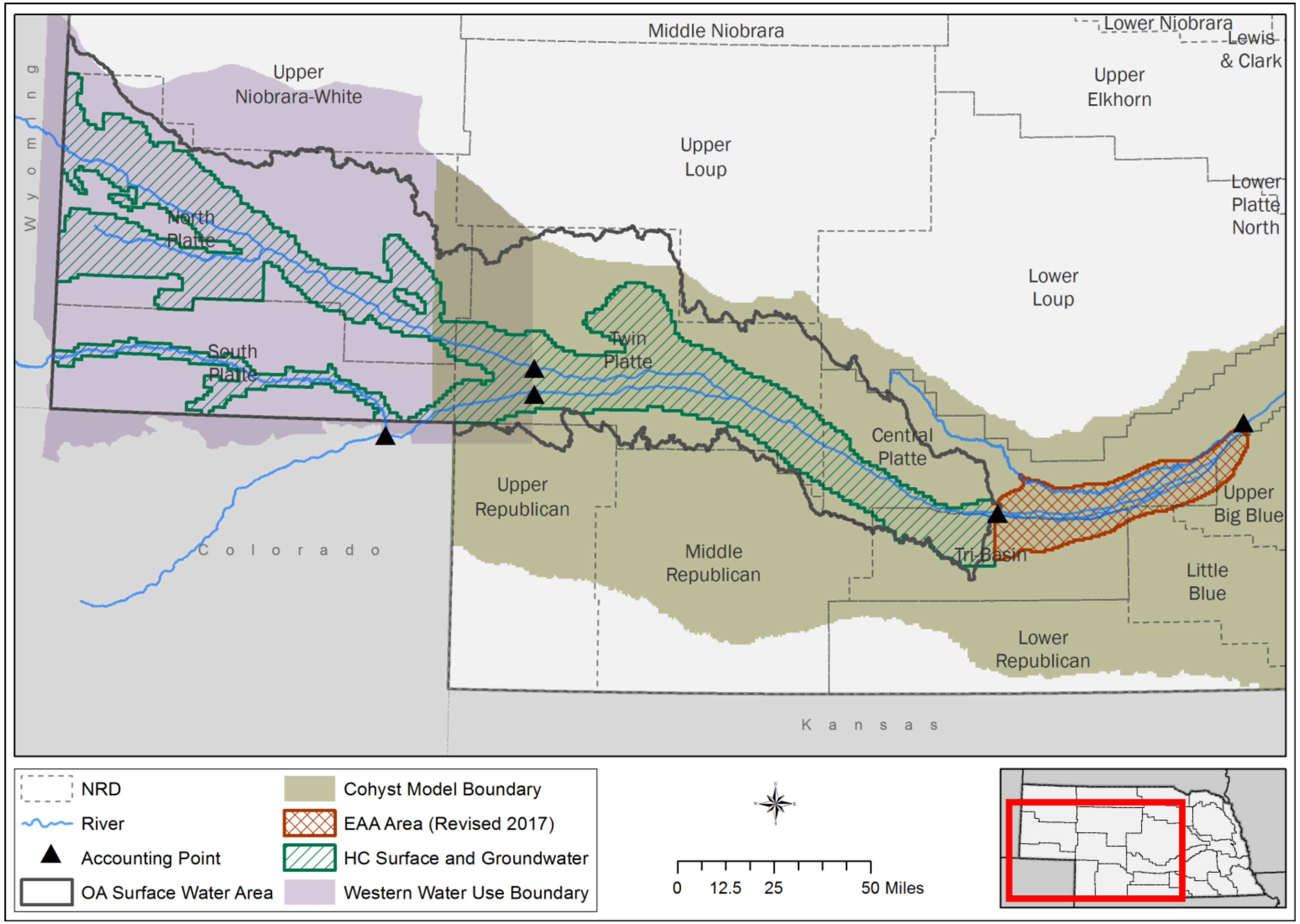
- **Complete monitoring activities outlined in the current IMP**
- **Assess progress on first increment goals and objectives**
- **Provide for more informed discussion of second increment objectives with the NPNRD IMP stakeholders**

Robust Review Model Simulation Setup

WWUMM Area Assumptions

- Used historical calibrated version of the groundwater and watershed models (Run 028/LU004/NIR set 2 for GW only lands)
- Model is simulated from 1953 – 2063
- Irrigation pumping repeats 2009-2013 in the baseline simulation and 1997 acres and crop types in the “1997” simulation with 2009-2013 weather repeated into the future
- Municipal and Industrial baseline simulation estimates use through time to 2013 and “1997” simulation is held constant
- Surface water and commingled acres remain constant in the baseline and 1997 simulations to cancel out commingled effects

Model Areas



Middle Niobrara
Lower Niobrara
Lewis & Clark
Upper Niobrara-White
Upper Elkhorn
Upper Loup
Lower Platte North
Wyoming
North Platte
Lower Loup
Twin Platte
South Platte
Central Platte
Upper Big Blue
Upper Republican
Tri-Basin
Middle Republican
Little Blue
Colorado
Lower Republican
Kansas
NRD
River
Accounting Point
OA Surface Water Area
Cohyst Model Boundary
EAA Area (Revised 2017)
HC Surface and Groundwater
Western Water Use Boundary
0
12.5
25
50 Miles

NPNRD Inputs
(Change in acres)

Change in groundwater-only irrigated acres 1997-2013

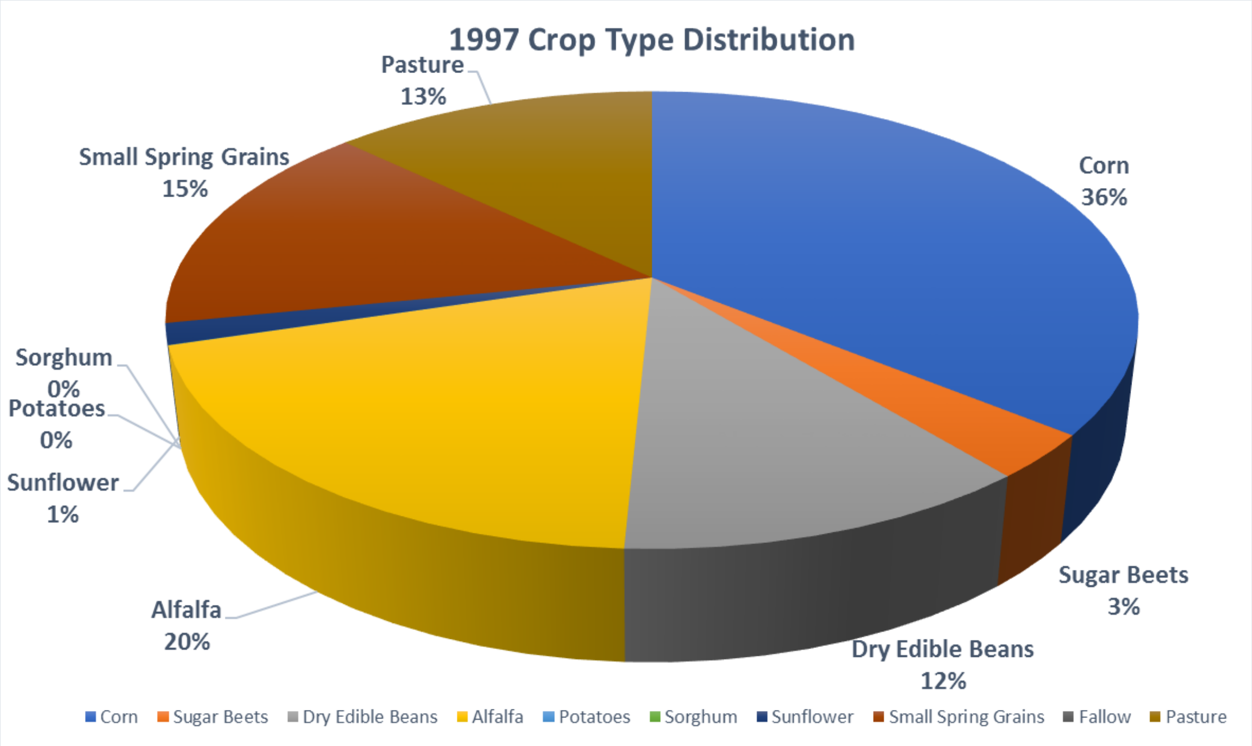
NPNRD	Total change (1997 to 2013)
District-Wide	-3,400 acres
OA	-5,400 acres

NPRD Inputs

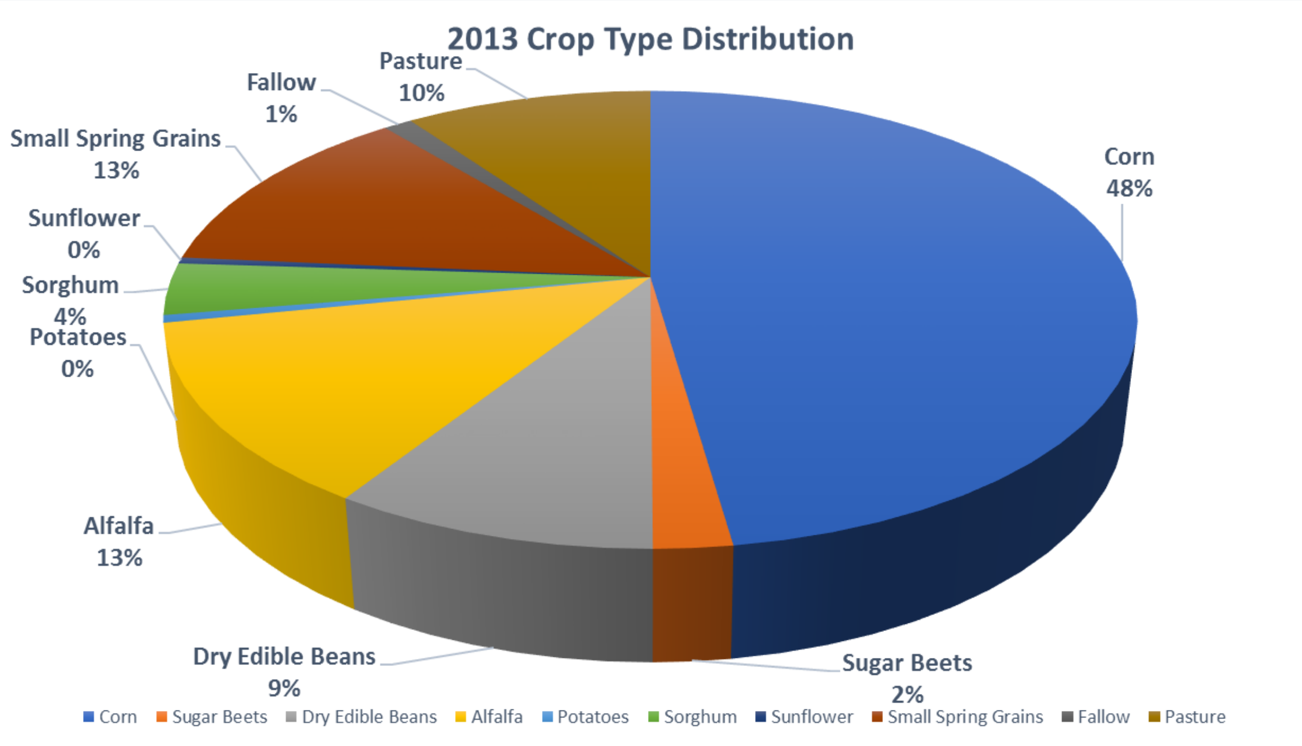
(Changes in crop type, district-wide)

Change in groundwater-only irrigated acre crop types 1997-2013

134,500 GW only irrigated acres



131,100 GW only irrigated acres

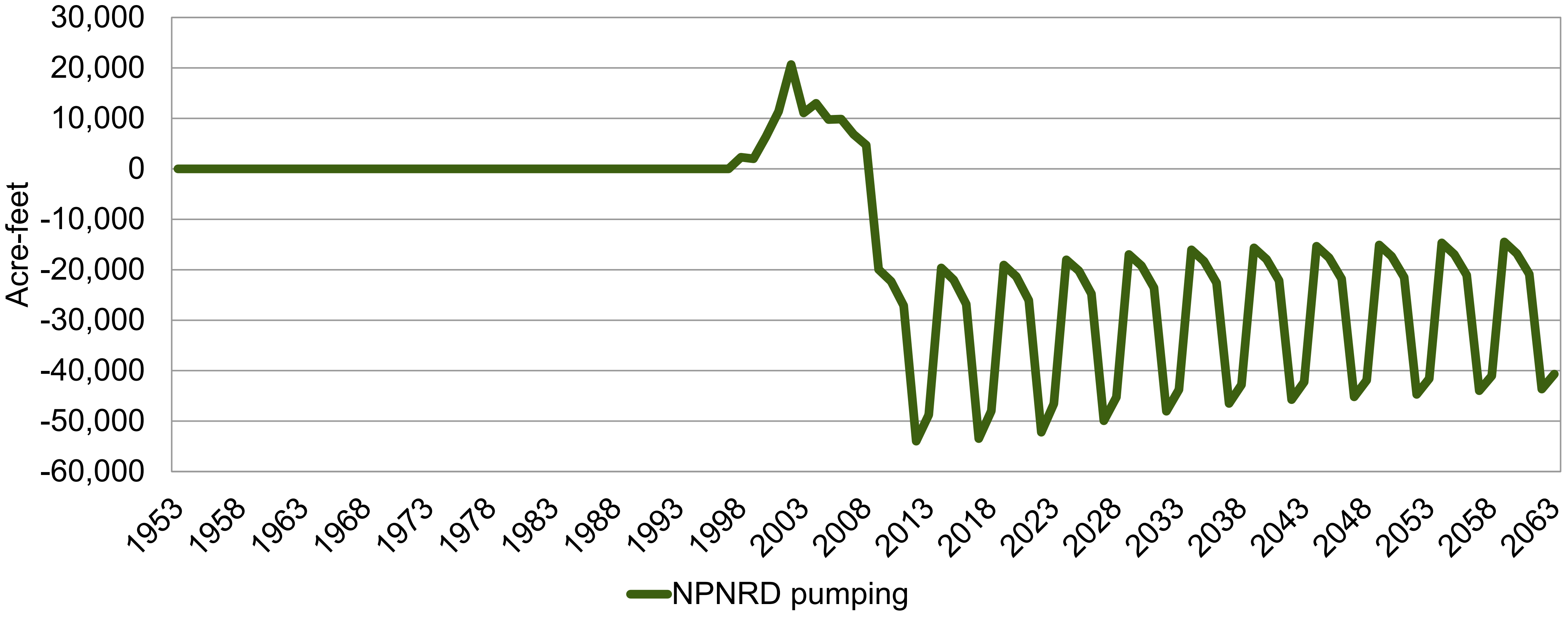


NPNRD Inputs

Current Estimates of Industrial and Municipal Pumping
Industrial average annual volume 14% lower (≈850 AF) compared to 1997.
Municipal average annual volume 4% lower (≈300 AF) compared to 1997
1997 = 5,472 AF industrial 7,639 AF municipal
2013 = 4,582 AF industrial 6,837 AF municipal

Changes to Post-1997 Pumping, District-Wide

Groundwater-only irrigation pumping (-3,400 acres) AND municipal/industrial uses



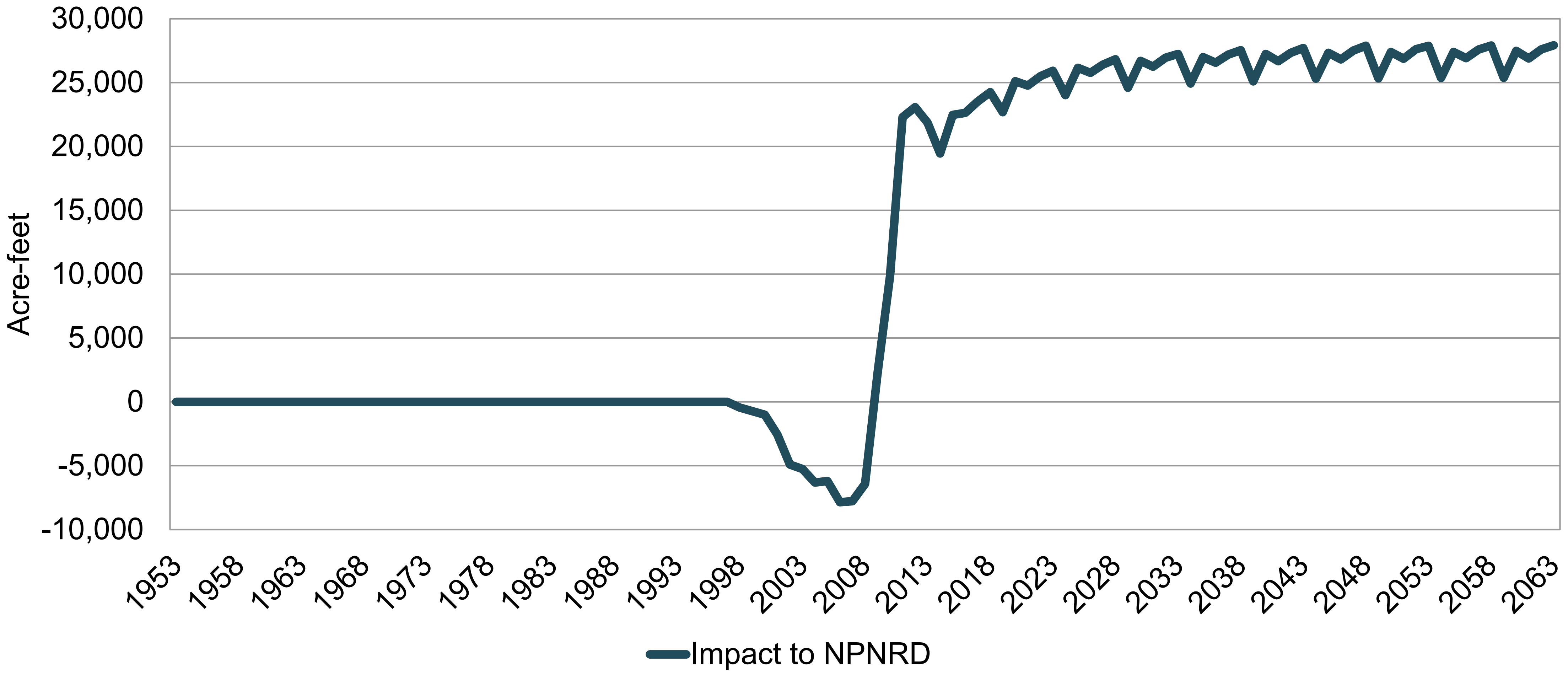
NPNRD Inputs
(Groundwater Recharge)

Excess Flows Diverted and Recharged into Canals in NPNRD

NPNRD	Acre-Feet of Excess Flow	
	Diversion	Recharge
2011	**61,260**	**28,739**

NPNRD Results

Total impact to NPNRD, from the Post-1997 **Changes** and Canal Recharge Event



NPNRD Summary

Post-1997 Estimates

NPNRD			
Year	**2019**	**2029**	**50-year**
Current IMP	-7,514		-8,000
Updated Estimate	22,000 – 24,500	24,000 - 26,000	25,000 - 27,900

- All values in acre-feet/year

Robust Review Analysis

Was a requirement of the first increment
Must be maintained in the second increment
Deals with Post-1997 Changes and Management Actions
It is the first step toward reaching a fully appropriated condition

NEBRASKA

DEPT. OF NATURAL RESOURCES

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Water Matters

Published by the Nebraska Department of Natural Resources

A guide to integrated water management in Nebraska

Stream Depletion and Groundwater Pumping

Part One: The Groundwater Balance

By Amy Ostdiek

While the information presented in this article is technical in nature, it has been generalized to appeal to a broader audience. This article provides an overview of a very complex topic.

The effect of groundwater pumping on streamflows has emerged as a major water issue and the source of many conflicts in several western states. In Nebraska, some conflicts have gone before the courts, including disputes over the Republican River Compact, the North Platte Decree, and between surface water appropriators and well owners in the Pumpkin Creek Basin, a North Platte River tributary in western Nebraska.

The Nebraska Legislature has passed substantial legislation attempting to resolve some of these conflicts twice in the past 15 years. In 1996, LB 108 encoded the hydrologic connection between aquifers and streams into state law and authorized natural resources districts (NRDs) and the Department of Natural Resources (DNR) to address conflicts. In 2004, LB 962 provided for proactive, integrated management of surface water and groundwater.

Successful management of the state's water resources requires an understanding of how groundwater supplies interact with surface water supplies. This edition of *Water Matters* is intended to provide a basic explanation of the way groundwater pumping can affect surface water, a key component at the heart of integrated management. Future editions will further explore this relationship and the complex effects (including the lag effect) of groundwater use.

Understanding the effects of groundwater use on streamflow

Though the individual relationships are varied and complex, groundwater aquifers in most of Nebraska are hydrologically connected to streams, and the two should be viewed as a single resource. The addition of water to either the aquifer or the stream will result in an overall increase to the hydrologically connected system over time. The removal of water from either the aquifer or the stream will result in a decrease over time (see figure 1).

As a general rule, the amount of water entering a system over the long term must equal the amount leaving the system, including any change in the amount stored in the system. In the shorter term, if inflows exceed outflows, the excess is stored and the water levels in the aquifer rise or the amount of water in the stream increases (or both). If the outflow is greater than the inflow to the system, water levels in the aquifer or stream decrease. If the amount of water entering the system stays relatively constant over the long term, as is typically expected, then any amount being removed (e.g., through groundwater pumping) will cause a reduction in storage or in the amount flowing out of the system.

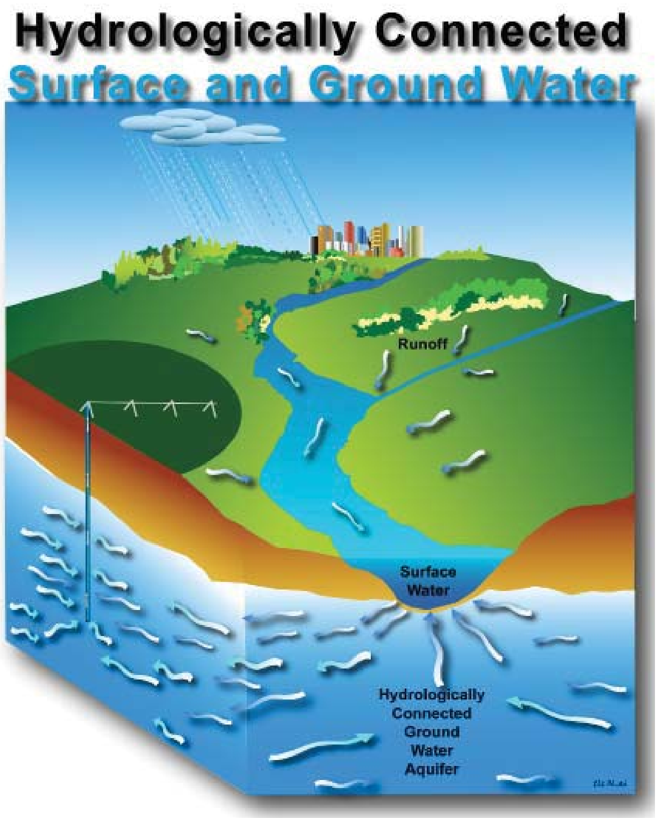


Figure 1: Hydrologically connected surface water and groundwater.

Prior beliefs that groundwater pumping can continue until the amount of groundwater withdrawn by pumping is balanced by the amount recharged to the aquifer by precipitation (also known as "safe yield") are not valid in hydrologically connected systems. This viewpoint assumes that a constant level of precipitation (recharge) will satisfy the groundwater withdrawals but fails to consider the necessity of the recharge to maintain or preserve streamflows.

Groundwater flow and the simple sandbox analogy

Unlike surface water flow, which is readily observed and measured, groundwater flow occurs below the land surface and is difficult to measure. This makes the effects of changes in groundwater flow more abstract and difficult to understand. Groundwater velocities are generally much slower than those of surface water. Groundwater often only moves a few feet per year, compared to typical flow rates of a few feet per second in rivers and streams. This slow movement of water occurs through the pore spaces between the rocks, sands, gravels, and other sub-surface materials. These sub-surface materials that store and transmit groundwater are called aquifers.

A simple way to think of an aquifer is as a sandbox filled with sand. When water is poured into the sandbox (addition of water to the system is called recharge), it fills the empty spaces between the grains of sand, much like groundwater in an aquifer. If there is a hole in the side of the sandbox, water will flow out of it until the water level in the box drops below the elevation of the hole. The hole in this case is like a river, and the flow out of the hole will depend on how full the sandbox is with water (or how quickly the sandbox is recharged with water to replace the water flowing out). In the absence of any other factors, the relationship between the amount of water being poured into the sandbox and the amount flowing through the hole will eventually come into equilibrium (see figure 2).

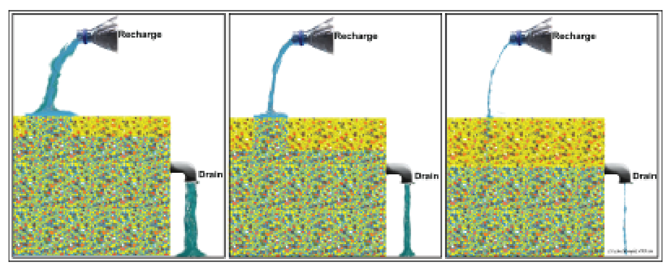


Figure 2: In a system with no additional factors (i.e. pumping), the amount of recharge will be equal to the change in storage plus the flow out the drain (or river)

If you dig a hole in the sand, you may see water fill in the hole (this is like many of the sandpit lakes and borrow pits along the Platte River and in other portions of the state). If you scoop water out of the hole with a cup, water will move into the hole from the surrounding sand. Scooping water out of the hole is like pumping a well. Like a well, it reduces the amount available to go out of the notch unless the amount of water being poured in (recharge) is increased (see figure 3).

Now, think of this type of system on a much larger scale. In a large system, the location of the hole

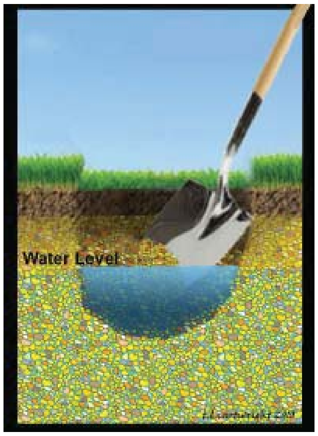


Figure 3: If you dig a hole in the sand, water will fill the hole. Scooping water out of the hole is like using a well. It decreases the amount of water in the system.

you dig in the sand box (i.e., well) to remove water relative to the drain (i.e., river) will affect how quickly flow of water out of the drain is reduced. Of course, increasing the flow into the sandbox (i.e., increased precipitation or recharge) will add water to the system, which may temporarily restore the amount of flow. However, this can't permanently mitigate the effects of the ongoing removal of water (i.e., groundwater pumping) unless the flow into the sandbox (recharge) continues to increase. Also, while the temporary increase in recharge may increase the water level in the aquifer (and consequently increase the amount of water flowing from the drain), it's important to remember that the effects of water withdrawn far away from the drain may not be fully realized at the location at which flow is being measured. Consider the complexity of a system like this as big as the High Plains Aquifer (also known as the Ogallala Aquifer), which covers roughly two-thirds of Nebraska (figure 4).

How does groundwater pumping affect the hydrologically connected system?

In a hydrologically connected surface water/groundwater system, depletions to streamflow due to groundwater pumping can occur either by wells that intercept water that otherwise would have flowed to the stream or by causing water to move from the stream to the well (see figure 5). In Nebraska, the first case is more common, though excessive levels of development and groundwater use can lead to the latter. So, as a typical well is pumped, water is initially removed from aquifer storage and over time this translates into less water reaching the stream. If pumping continues to the point that the water level in the aquifer is lower than the water level of the stream, water would flow from the stream into the aquifer to replenish aquifer storage and supply the well.

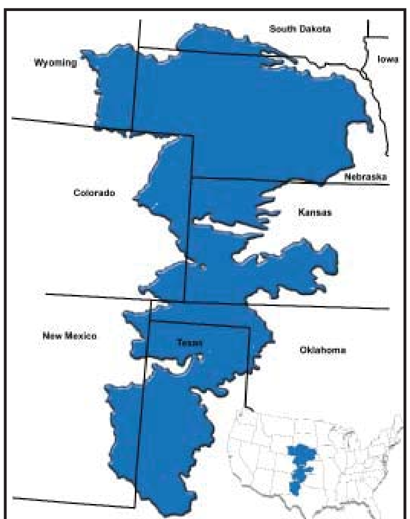


Figure 4: The High Plains Aquifer

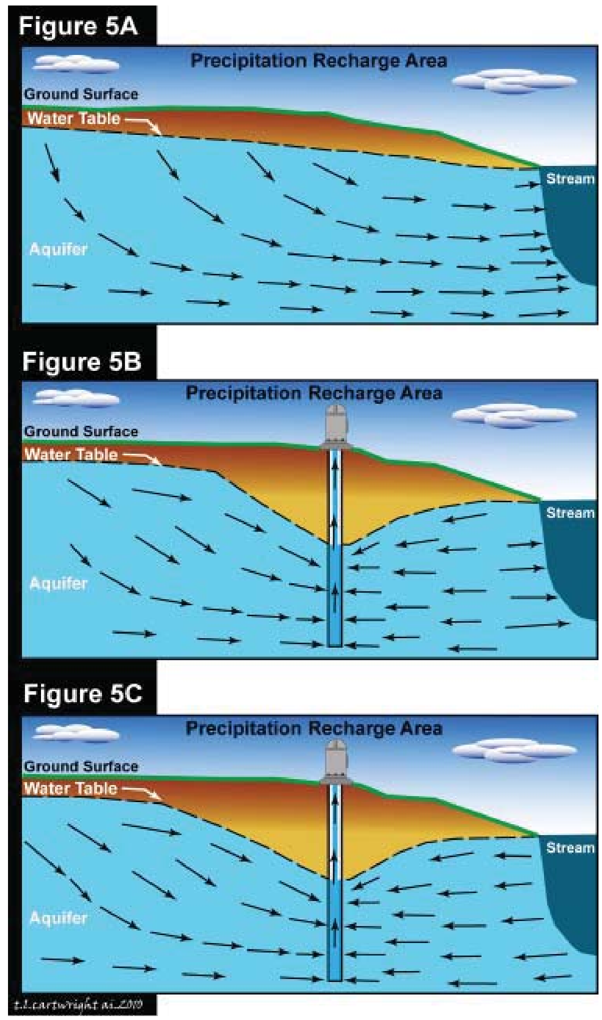


Figure 5: If a well starts removing water from the aquifer (5B), the well will intercept water that otherwise would have flown to the stream. As the well continues to pump, more water is removed from the system and less water reaches the stream. Eventually, if pumping continues, water will flow directly from the stream toward the well (5C).

Groundwater models (analytical and numerical) must be used to understand and predict streamflow depletions. Depletions are determined by calculating the difference between the streamflow that would have occurred if the well was not pumped and the streamflow that occurs when a well is pumped (figure 6). Many factors within a model can change the time it takes for a pumping well to affect water supply, such as the properties of the aquifer, intensity and duration of the pumping, the presence or absence of a clogging layer within the streambed, and distance to the stream. In many areas of Nebraska significant efforts have been and are being made to refine our understanding of these properties, which will help us to further understand the timing aspects of depletions. However, all pumping[1] in the hydrologically connected system must eventually result in a near 100% depletion. In other words, if one acre-foot of water is pumped, there will be one acre-foot less water in the system, even though the effect may not be realized instantaneously. The next issue of *Water Matters* will provide an in-depth discussion of the lag effect of groundwater pumping and other timing-related issues of stream depletions.

When does streamflow depletion become a concern?

There are many factors that may determine how much streamflow depletion due to groundwater use is acceptable in a given area, such as interstate compacts or decrees and the rate of past and predicted future development. For this reason, the definition of effective management can vary greatly by area. Not only are there different restrictions in various areas across the state; stakeholders also have different priorities. Therefore, the type of management utilized must be receptive to changes in circumstances and provide for monitoring of how those circumstances may change through time. That is why the integrated management process (read more about the integrated management process in *Water Matters*, No. 1) is so critical to successful preservation of Nebraska's water resources.

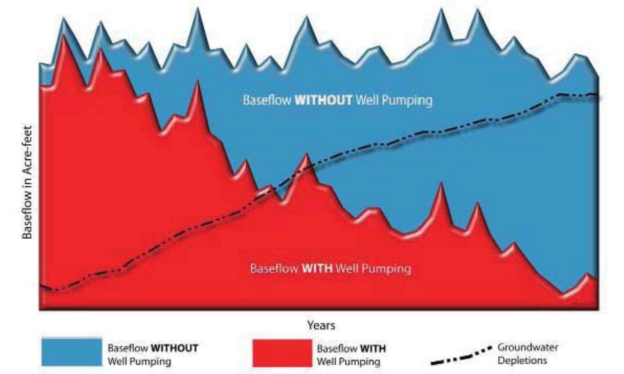


Figure 6: An example of how groundwater pumping may affect streamflow.

Through the integrated management process, Nebraska must ensure that it is able to meet its interstate obligations. The process should also be used to respond flexibly and responsibly to the area's needs and priorities. Conceptually, and by law, an integrated management plan is always a work in progress for either maintaining a balance of the hydrologic system or regaining a balance. As the affected area changes and more data become available, an IMP must be reassessed, evolving as needed to accommodate changing circumstances, which may include hydrology, economics, water demands, and stakeholder priorities.

[1]Groundwater pumping in this document is intended to represent water that is pumped and consumed. The remainder will either return to the aquifer as recharge, or run off and become streamflow.

This edition of *Water Matters* will be referenced and discussed in the July 2010 DNR newsletter.

NEBRASKA Department of Natural Resources

Please contact the Nebraska Department of Natural Resources with questions or concerns about this publication at 471-2363.

Visit the Integrated Water Management Division's website at http://www.dnr.ne.gov/IWM for up-to-date information. *Water Matters* is available at this website.

July 2010 No. 5

Water Matters

Published by the Nebraska Department of Natural Resources

A guide to integrated water management in Nebraska

Stream Depletion and Groundwater Pumping

Part Two: The Timing of Groundwater Depletions

By James Schneider, Ph.D.

While the information presented in this article is technical in nature, it has been generalized to appeal to a broader audience. This article provides an overview of a very complex topic.

Introduction

In most areas of Nebraska, the groundwater system is in direct hydrologic connection with the surface water system. Therefore, the consumptive use of groundwater will have some impact on the amount of groundwater discharge (baseflow) to hydrologically connected streams. Reductions in baseflow due to groundwater pumping are not instantaneous, and may take many years or decades to be fully realized. The time lag between the start of pumping and the advent of streamflow depletions is largely dependant on the distance between the well and the stream, as well as the aquifer and streambed properties.

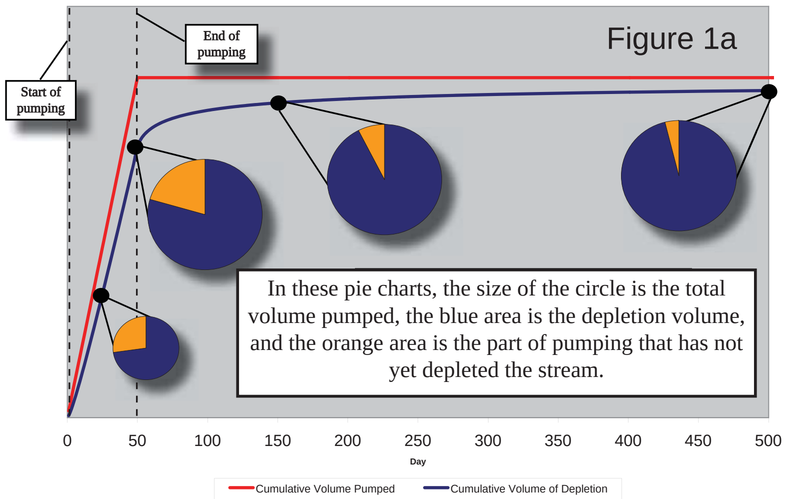
One factor that will affect lag time is the level of hydraulic conductivity of the materials in the aquifer. Hydraulic conductivity is a measure of the ease with which water travels through aquifer materials. Wells installed near a stream and/or in high hydraulic conductivity materials will have a quicker impact on the streams. Wells installed far from a stream and/or in lower hydraulic conductivity areas can take considerably longer to impact nearby streams (see figures 1a, 1b, and 1c on page 2).

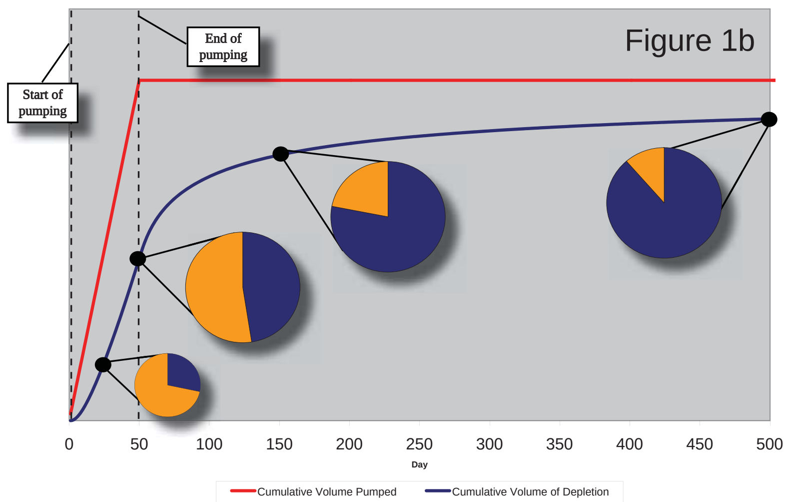
Generally speaking, any consumptive groundwater pumping[1] in a hydrologically connected stream/aquifer system will eventually result in a similar level of stream depletion. However, in a large regional aquifer system such as the High Plains Aquifer in Nebraska (sometimes referred to as the Ogallala Aquifer), this stream depletion due to groundwater pumping during a given year will likely not be realized for many years.

The Timing of Stream Depletions

Stream depletions cannot be directly measured. Therefore, groundwater models are widely used to simulate past and predict future impacts to streams due to groundwater use. A calibrated groundwater model can be run with and without estimated past pumping rates. The difference between the baseflow to the streams for these two scenarios is referred to as stream depletion due to groundwater use. The model can then be run forward in time using similar scenarios

[1]Groundwater pumping in this document is intended to represent water that is pumped and consumed. The remainder will either return to the aquifer as recharge, or run off and become streamflow.





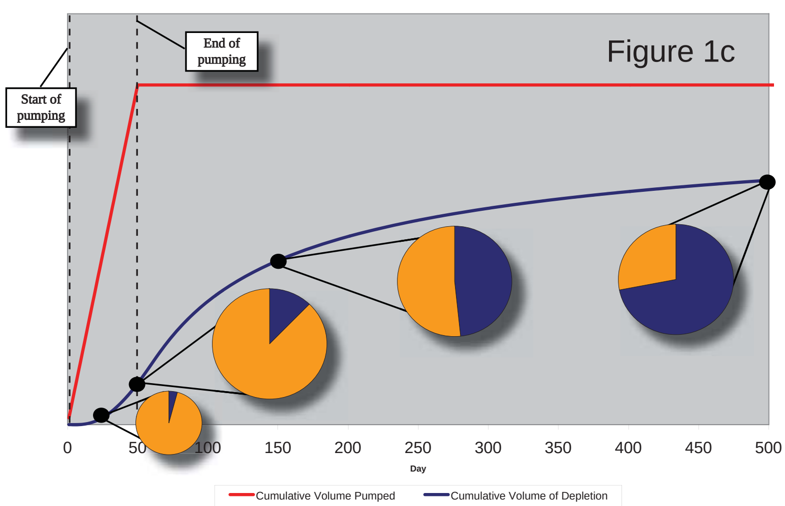
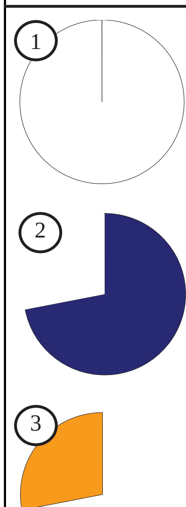


Figure 1 (a, b, c): Three hypothetical scenarios in which three different wells pump for 50 days. In all three of these scenarios, the wells pump the same volume of water. The red line shows the cumulative volume of groundwater that is pumped and the blue line represents the volume of depletion to streamflow. Again, in all three of these scenarios, the cumulative volume pumped is the same. However, the rates of depletion differ significantly. Even though the depletion rates differ, it is important to note that in all three scenarios, the volume of groundwater pumped and the volume of the depletion will eventually be nearly equal. This means that all pumping will eventually result in a near 100% depletion. However, the amount of time it takes for the depletion to be fully realized will differ depending on depletion rate. For example, in figure 1a, roughly 96% of the volume of groundwater pumped has depleted the stream after 500 days. In figure 1b, roughly 89% of the volume of groundwater pumped has depleted the stream after 500 days. And in figure 1c, roughly 72% of the volume of groundwater pumped has depleted the stream after 500 days. The pie charts show the volume of streamflow depletion relative to the volume of water pumped. The depletion rate (and therefore the depletion volume) will depend on many factors, such as aquifer properties and distance to the stream.

Explanation of Pie Charts in Figures 1a, 1b, and 1c



The pie charts in figures 1a, 1b, and 1c show the amount of streamflow depletion relative to the volume of water pumped. Here, pie chart 1 represents the height of the red line, which is the entire amount pumped. Pie chart 2 represents the height of the blue line, which is only the depletion due to groundwater pumping at day 500 in figure 1c. Note that the pie chart is incomplete: there is a portion of the full pie (which represents the volume of water pumped) that is missing. Pie chart 3 is that missing piece. The orange area represents the difference between pie charts 1 and 2, which is the distance between the red and blue lines. This is portion of the groundwater pumping that has not yet been realized as a depletion.

to estimate projected stream depletions due to past, current, and/or future groundwater use.

To better understand this long-term relationship between groundwater pumping and stream depletions, it is useful to separate streamflow depletions for a given basin into two components that are best understood in terms of some reference year (any appropriate year against which future depletions are measured). Relative to this reference year, there are residual impacts to streamflow from pumping that has occurred in the past and there are the lagged impacts of current pumping levels continuing into the future. Model scenarios can be used to illustrate the relative amount of each of these factors in the projected future streamflow depletions.

Residual Depletions

The scenario in figure 2 illustrates the residual impacts to streamflow from pumping that has occurred in the past (i.e. up to the reference year). It is important to note that in figures 1a, 1b, and 1c, *cumulative volumes* of pumping and depletion were shown. However, in the upcoming figures, pumping and *depletion rates* are shown. While cumulative volume measurements reflect the total volume of water pumped or depleted up to a given time, the rate is the volume of water pumped or depleted at one specific point in time.

The bars in figure 2 represent the amount of groundwater pumping during a given year (the rate of groundwater pumping), and the line represents the impact of this pumping on streamflow (this rate of streamflow depletion may be affected by pumping that has occurred in the past). The short term variability in the depletions curve is due to changes in year-to-year rainfall totals, which also affect the amount of streamflow. In this example, groundwater pumping has increased up to a given level through year six (the reference year in this scenario), after which all current pumping is set to zero. Despite the fact that no further pumping occurs beyond year six in this example, baseflow to the stream continues to be depleted due to continued effects of pumping that occurred during and before year six. This is referred to as the residual effect.

The residual effect has both a time component and a streamflow depletion component. The residual depletion is the streamflow depletion remaining during any given year after the reference year due to pumping that has occurred up to that reference year. The recovery time is the length of time after the reference year required for the residual depletions to approach zero.

The information on residual depletions and recovery time is compiled by running a groundwater model through this scenario. The model is run up to the reference year with groundwater use active, then it is run forward beyond the reference year with all pumping removed to quantify the recovery of baseflow to the streams. In this example, year six is the reference year, and the residual depletions approach zero sometime around year 41, for a recovery time of approximately 35 years (figure 2).

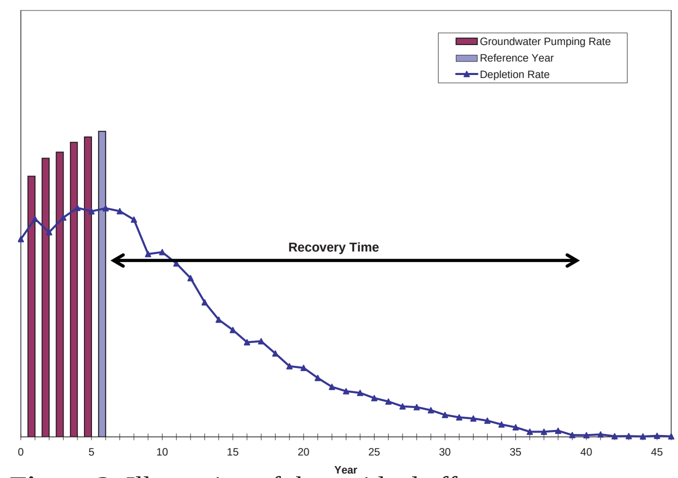


Figure 2: Illustration of the residual effect.

Lagged Depletions

Figure 3 illustrates a modeling scenario demonstrating the lagged impact to streamflow due to current levels of pumping. Here, groundwater pumping has been increasing until year six (reference year), at which time a hypothetical moratorium is placed on further well development in this basin, which is modeled as constant pumping for every year after the reference year (year six). This time, however, the model is run beyond the reference year with a constant level of pumping to assess the depletions to the stream due to past and current levels of water use. As in our first scenario, we observe short-term fluctuations due to the effects of annual precipitation variability. However, streamflow depletions will continue to increase despite the constant level of pumping. This is referred to as the lag effect. The depletions curve generated in this

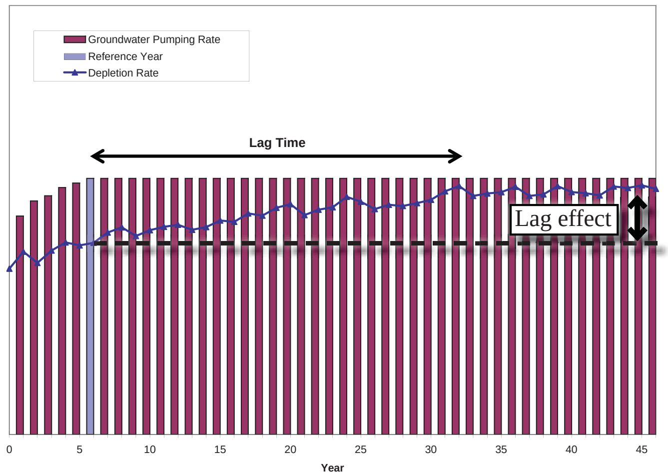


Figure 3: Illustration of the lag effect.

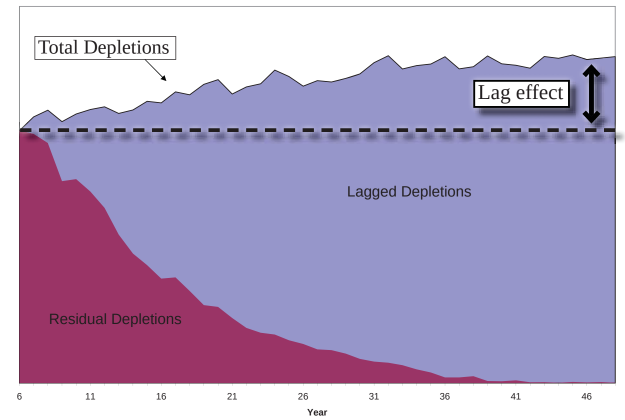


Figure 4: The residual and lagged components of total depletion beginning at the reference year (year 6).

scenario includes both the residual and lag depletions.

The lag effect also has a time and streamflow depletion component. The lag time is the length of time before the streamflow depletions come into equilibrium with continued groundwater pumping, and is defined in relation to a reference year. In this model scenario, the streamflow depletions appear to begin to reach equilibrium with respect to year six levels of pumping around year 36, for a lag time of approximately 30 years (figure 3). The lagged depletions for a given year are the difference between the residual depletions and the total depletions (figure 4).

Summary

The successful management of hydrologically connected waters requires an understanding of the complex effects of groundwater pumping on stream baseflow. The timing of the components of stream depletion are most easily discussed relative to points in time (a reference year) with an eventual realization of all consumptive groundwater withdrawals as stream depletions, years to centuries in the future. Understanding the timing of these effects and the response of hydrologically connected streams to groundwater pumping is critical in long–term management and planning.

This edition of *Water Matters* will be referenced and discussed in the October 2010 DNR newsletter.

NEBRASKA Department of Natural Resources

Please contact the Nebraska Department of Natural Resources with questions or concerns about this publication at (402) 471-2363.

Visit the Integrated Water Management Division's website at http://www.dnr.ne.gov/IWM for up-to-date information. *Water Matters* is available at this website.

February 2014 No. 8

Water Matters

Published by the Nebraska Department of Natural Resources

A guide to integrated water management in Nebraska

Balancing Water Supplies Through Groundwater Recharge

Part One: A Component of the Conjunctive Management Toolbox

Key concept

Hydrologic processes in many areas of the state involve a cycle in which water diverted from streams seeps through the soil into a groundwater storage system called an aquifer. Completion of this cycle involves areas of hydrologic connection where water stored in an aquifer can discharge back into a stream or river. Through integrated water management techniques, this natural process can be enhanced and controlled, making water more readily available for human use with positive streamflow impacts.

Introduction

Since the turn of the century many western states, including Nebraska, have developed substantial surface water reservoir storage capacities to purposely retime streamflows. Retiming of streamflows is done by blocking a portion of a stream's flow, storing it in a reservoir, and then returning it to the stream at a later time. Reservoirs such as Lake McConaughy, Harlan County Reservoir, and Merritt Reservoir represent a few such storage facilities in Nebraska. The retiming of water supplies provided by surface water storage facilities allow for utilization of the water resources for benefits such as irrigation, power production, and recreation.

While the value of using surface water reservoirs is understood by most water users, many are unaware that water can also be purposely stored in underground reservoirs, also known as aquifers. In order to maximize water use and minimize negative impacts on streamflows and groundwater levels, conjunctive management uses the connection between surface water and groundwater aquifers to store water underground, thereby increasing the availability and reliability of the water supply in a region[1]. In other words, conjunctive management optimizes use of the whole water supply. Diverting stream water to allow it to seep into the aquifer during times of excess flow can help mitigate streamflow shortages that occur in subsequent periods. One way that excess flows can be stored in the aquifer is by diverting that water into existing canals and allowing seepage to occur via the canal bottom (figure 1). Under the authorities of an integrated management plan and the Ground Water Management and Protection Act (the Act), conjunctive management projects can be implemented that divert excess streamflows for the purpose of achieving and sustaining a balance between water uses and water supplies. To support the efforts of implementing conjunctive management projects, this edition of *Water Matters* provides a brief examination of the value of purposely storing water underground in order to increase groundwater discharge to streams and help achieve a sustainable water balance.

[1]California Department of Water Resources. (2009). Conjunctive management and groundwater. *California Water Plan Update 2009*, 1-25.

While the information presented in this article is technical in nature, it has been generalized to appeal to a broader audience. This article provides an overview of a very complex topic.

Utilizing Excess Flows

A stream can experience reduced flow in part due to variability in precipitation, reservoir storage, and the effects of beneficial uses of surface water and groundwater. Because of the variability of flow, the supply may not meet the demands at any given time. At other times there may be more than enough water, or excess flow, to satisfy all the beneficial uses on a given stream. It can be advantageous to store and retime excess streamflows for occasions when the water supply is insufficient to meet the demands. Implementing conjunctive management projects to utilize aquifers as extensions of available storage increases the available storage capacity. These projects potentially require less capital investment than a new surface water reservoir while still providing long-term benefits to the future water supply.

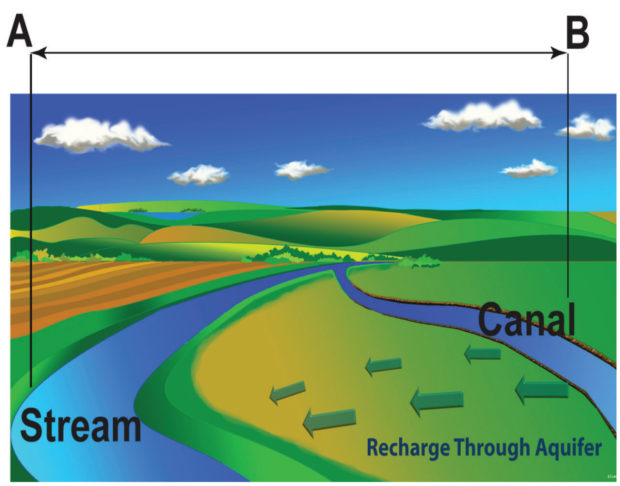


Figure 1: Schematic diagram illustrating the diversion of excess flow from the stream to the canal and the direction of groundwater recharge through the aquifer.

Retiming streamflows can be done using two different approaches: active or passive. The active approach includes mechanical methods such as pipes, tanks, pumps, and reservoirs for moving the water back to the stream. Mechanical methods for moving and storing water can be expensive, often requiring significant investment in infrastructure and continued operation and maintenance costs. Mechanical methods have the advantage of supplying more control over timing and amount of water; operationally, a pump can be utilized at the flip of a switch to supply water. The passive approach, such as the diversion of excess streamflows, minimizes the use of man-made structures and takes advantage of the natural hydrologic properties of near-stream aquifers. The passive approach gives the operator less control over when water is supplied to the stream than the mechanical method, but typically requires less cost.

A single groundwater recharge event continues to influence streamflows over a period of years or decades.

Nebraska is fortunate to have large aquifers adjacent to most of its streams that can be used for conjunctive management, serving as storage reservoirs for excess water and providing a conveyance mechanism for its return to the stream. Purposely storing water in an aquifer can be referred to as groundwater recharge, artificial recharge, or aquifer storage and recovery. These techniques have the potential to increase water storage levels in the aquifer and also increase groundwater discharge, or accretion, to streams.

Several techniques for groundwater recharge have been widely studied and implemented. In many cases, wells are used to inject and store water in a deep aquifer to be recovered later. In other situations, irrigation canals and drains can also be used to direct excess surface water flows into an aquifer. An open, unlined canal that is filled with excess streamflow can seep water into the aquifer below, and through time, that recharged water will gradually flow underground and find its way back to the stream as baseflow (see figure 1 and the cross-section of points A and B shown in figure 2). The concept that unlined canals provide water to groundwater aquifers through recharge has been well understood in Nebraska for over a century.

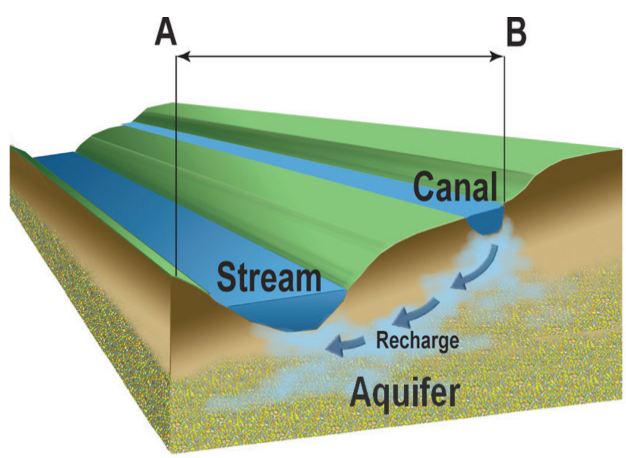


Figure 2: Schematic diagram illustrating the seepage of excess flow from the canal into the groundwater aquifer and subsequent return path of water to the stream.

Quantifying the Benefits

When excess water is diverted from the stream, a portion of it may return as runoff to the stream through surface return ditches, and a portion of it may recharge into the groundwater aquifer to return to the stream at a later point in time as baseflow. The rate at which recharged water returns to the stream as baseflow depends upon how easily the water can move through the soil and rocks of the aquifer and the distance from the canal to the stream. How fast the effects due to recharge occur throughout the aquifer is dependent upon characteristics such as the amount of connected pore space in the soil and the effective thickness of the aquifer. Many mathematical equations have been developed to estimate the quantity and timing of this returning water. One such mathematical function was described by Hunt[2] in 1999. The "Hunt Method" strives to calculate how much water will return to the stream over time, using aquifer characteristics, streambed characteristics, and distance from the stream. For a one-time diversion and recharge event (pulse), the accretion to the stream over time generally looks like the graph shown in figure 3.

Figure 3 illustrates that a single groundwater recharge event continues to influence streamflows over a period of years or decades. As an aquifer's ability to transmit water varies from location to location, and because canals lie at different distances from the stream, the response to the stream for each canal (or different sections of a single canal) will differ. Figure 4 illustrates a range of accretion rates to the stream, calculated for aquifers with varying ability to transmit water and located at varying distances from the stream. For a project with a fast response, most of the estimated accretion occurs rapidly. For moderate or slow responses, the maximum instantaneous accretion rate is lower, but persists at a higher level for much longer. Both figures 3 and 4 show that, for a single event, as water discharges to the stream the amount of accretion reaches a maximum instantaneous value at some point after the event, and then the effect gradually diminishes.

It can be advantageous to store and retime excess streamflows for occasions when the water supply is insufficient to meet the demands. Implementing conjunctive management projects to utilize aquifers as extensions of available storage increases the available storage capacity.

Figures 3 and 4 depict the response of the stream to a single groundwater recharge event, or pulse. Increased benefits to the system can occur if the groundwater recharge events are repeated through time.

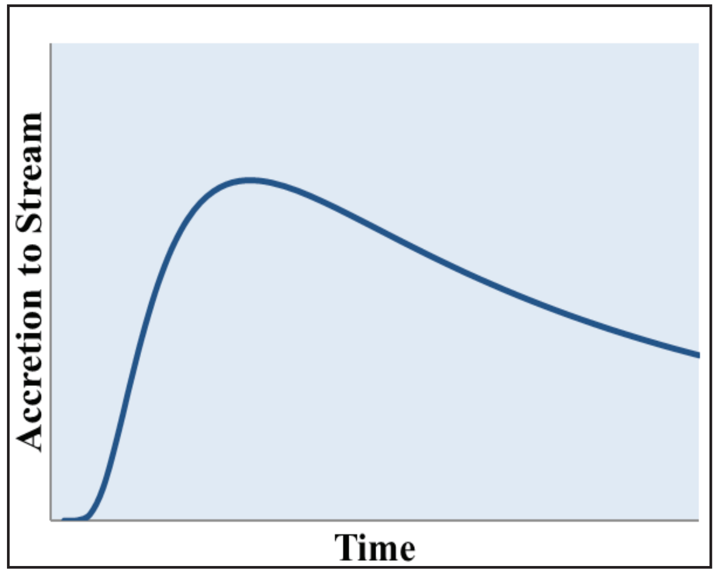


Figure 3: Illustration of typical accretion to streamflow from a single groundwater recharge event.

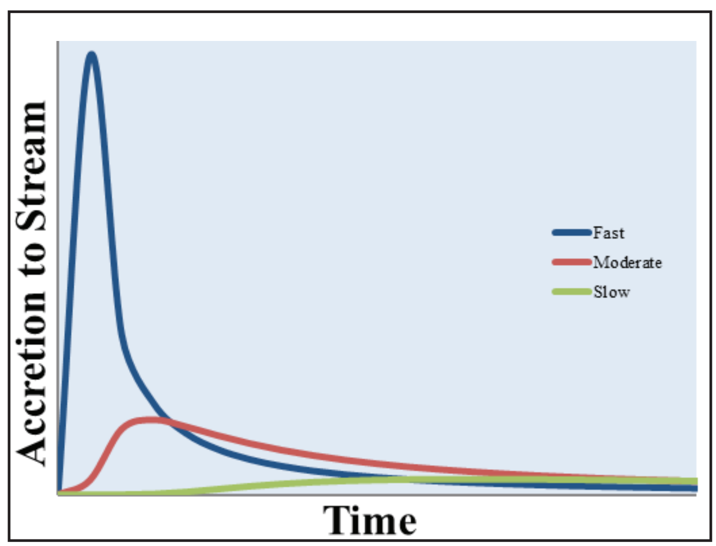


Figure 4: Graph illustrating fast, moderate, and slow response times and accretion rates.

[2]Hunt, B. (1999). Unsteady stream depletion from ground water pumping. *Ground Water*, *37*, 98-102.

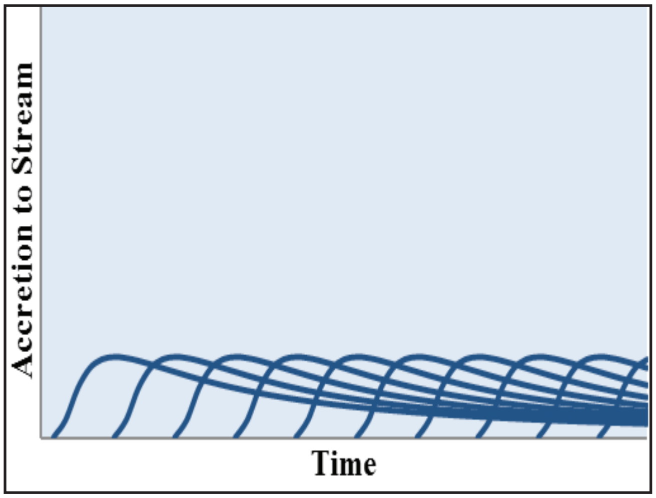


Figure 5: Multiple applications through time: each curve represents a single event, like that shown in figure 3. Calculating each accretion individually and plotting them on a single graph looks like a simple sequence of accretive events.

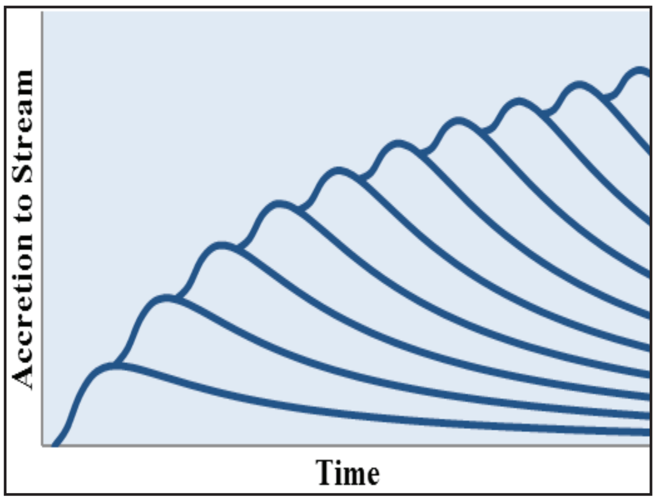


Figure 6: Multiple events accumulate flow: the true benefit of multiple events is not fully realized until the additive effects are shown as here, where each individual event from figure 5 is added to the previous event(s) to demonstrate the additive effect of using numerous opportunities to store excess flow in the aquifers under canals.

The State of Nebraska has the technical and administrative tools available to design, implement, and evaluate the benefits of a groundwater recharge project.

Figures 5 and 6 show how purposeful groundwater recharge events applied over time will create an aggregate, long-term accretion to the stream.

Conclusions

Conjunctive management actions aimed at developing groundwater recharge projects take advantage of excess streamflows and can retime those flows to be available to the stream in the future. If recharge events are implemented on a recurring basis, these projects have the potential to supply significant amounts of water to the stream. The State of Nebraska has the technical and administrative tools available to design, implement, and evaluate the benefits of a groundwater recharge project.

Conjunctive management strategies hold the potential to increase available storage capacity in order to mitigate flooding, protect rivers, and provide long-term benefits to future water supplies. Projects that employ methods of conjunctive management can have many positive outcomes, including minimal capital investment due to the use of existing infrastructure, and little, if any, negative effects. *Water Matters*, No. 9 describes such a project, outlining a groundwater recharge project undertaken cooperatively by the Department of Natural Resources with local natural resources districts and irrigation districts located along the Upper Platte River. Details of the project's implementation and lessons learned from the resulting data verify that conjunctive management of surface and groundwater resources can be a very adaptable and widely beneficial approach.

In *Water Matters*, No. 9, a pilot project is described in which the theoretical concepts outlined above are demonstrated in a real world setting.

Nebraska
Department of Natural Resources

Please contact the Nebraska Department of Natural Resources with questions or concerns about this publication at (402) 471-2363.

Visit the Integrated Water Management Division's website at http://www.dnr.nebraska.gov/IWM for up-to-date information. *Water Matters* is available at this website.

February 2014 No. 9

Water Matters

Published by the Nebraska Department of Natural Resources

A guide to integrated water management in Nebraska

Balancing Water Supplies Through Groundwater Recharge

Part Two: A Conjunctive Management Demonstration Project

Key concept

A conjunctive management demonstration project was conducted in 2011 on the Upper Platte River in order to more accurately quantify and manage the complex relationships between hydrologically connected surface water and groundwater resources. Throughout the project's planning, coordination, and implementation phases, project sponsors demonstrated the ability to divert and store excess flows in order to increase the availability and reliability of water supplies in the future, while also mitigating the negative impacts of flooding events.

Introduction

Water resources in Nebraska are managed in order to best serve the interest of the state's citizens. The storage of water in the state's aquifers has been determined to be a beneficial use of water resources. Properly managing hydrologically connected water resources is essential not only to maintain the economic and physical well-being of the Nebraska's citizens, but also to ensure that these vital resources are available for use at the most opportune time and location. Given that water resources and those who depend on them are vulnerable to extremes in regard to quantity, an adept and comprehensive method of managing these resources is required.

Water Matters, No. 8 described the hydrologic basis and authority under which conjunctive management projects can be implemented. Techniques for conjunctively managing hydrologically connected surface and groundwater resources provide managers with a broad set of options through which the use of these resources can be optimized, while minimizing inefficiencies and other negative impacts on users and the environment. At times, the availability of water resources is frequently out of balance with user demand and the occasions at which these inconsistencies might arise can be highly variable.

Image 1: Photograph of a canal used during the 2011 groundwater recharge demonstration project.

While the information presented in this article is technical in nature, it has been generalized to appeal to a broader audience. This article provides an overview of a very complex topic.

This edition of *Water Matters* describes a cooperatively undertaken conjunctive management demonstration project that was initiated in order to determine the potential ability of the aquifer adjacent to the Upper Platte River to store excess surface water flows for later use. Numerous benefits were realized through the implementation of this project, including a quantification of the timing and rates of groundwater recharge and accretion along the Upper Platte River, as well as a demonstration of the ability of managers to use the existing hydrology and infrastructure of the region to mitigate negative impacts of flooding events. Additionally, the project provided an opportunity for the project sponsors to demonstrate their capability for coordination and implementation of timely conjunctive management action when an opportunity presents itself.

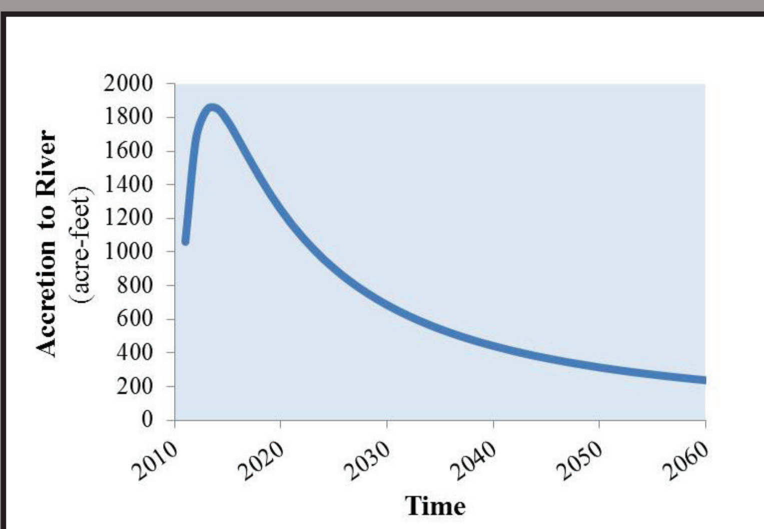
Demonstration of the Process

In the late winter and early spring of 2011, the Bureau of Reclamation projected potential flood flows on the North Platte River. These flood flows were expected to be in excess of all demands. With this understanding, the Department of Natural Resources (Department), several natural resources districts (NRDs), and multiple irrigation districts began a demonstration project to evaluate the effects of diverting excess streamflow into existing canals. In addition to recharging groundwater and adding accretions to streamflow, another expected benefit of the project was the mitigation of the flooding predicted by the Bureau of Reclamation.

In the late winter and early spring of 2011, the Bureau of Reclamation projected potential flood flows on the North Platte River.

In order to carry out the project, applicable surface water appropriation permits were applied for by the irrigation districts and subsequently approved by the Department. Part of the permit application process included demonstrating that excess flows were available in the Platte River system. In 2010, a report on the availability of excess flows in the Platte River was compiled and published by the Department. The purpose of the report was not only to evaluate the historic quantity of excess flows in the Platte River, but also to assist managers in the development of a planning tool that could be used to estimate the approximate duration and frequency of those flows.

Ultimately, the results of the streamflow study showed that excess flows are available on a periodic basis and can be utilized for recharging groundwater storage. Combined with the data gathered from the groundwater recharge project and other pertinent investigations, the excess streamflow study provided valuable information to Nebraska's water managers. More details about the excess streamflow study and the full report can be found on the Department's website at: http://dnr.nebraska.gov/iwm/historic-platte-river-streamflow-excess-protected-target-flows.



Year	Estimated Annual Accretion to River (acre-feet)
2011	1,062
2020	1,251
2030	685
2040	442
2050	315
2060	238
10-year Cumulative Benefit	**15,474**
50-year Cumulative Benefit	**36,168**

Figure 1, Table 1: Estimated accretions to the river resulting from the 2011 recharge demonstration project.

Once the necessary permits were approved, excess flows were diverted throughout the early spring until irrigation season began, and again in the fall once irrigation season was over. The Department's Bridgeport Field Office, in conjunction with the NRDs and irrigation districts, monitored the diversions of the stream to each canal as well as many of the diversions' canal returns back to the river. Image 2 shows a dry canal before the project began and image 3 shows a canal filled with diverted water during the project. A significant accomplishment of the demonstration project was the cooperative manner in which the project sponsors worked through the required administrative procedures to obtain permits and coordinated monitoring responsibilities. Demonstrating the capability to effectively collaborate on a complex project such as this ensures that a timely response can be made in the event of a flood flow prediction.

The demonstration project diverted 141,911 acre-feet of water. The estimated amount of water purposefully recharged into the aquifer was 64,699 acre-feet, with 36,168 acre-feet of the recharge expected to reach the river as accretions within 50 years.

Diversion Canals	
▪ Belmont Canal	▪ Minatare Canal
▪ Castle Rock Canal	▪ Nine Mile Canal
▪ Central Canal	▪ North Platte Canal
▪ Chimney Rock Canal	▪ Orchard-Alfalfa Canal
▪ Cozad Canal	▪ Pathfinder Canal
▪ Dawson Co. Canal	▪ Paxton-Hershey Canal
▪ Enterprise Canal	▪ Phelps County Canal
▪ Farmers Canal	▪ Suburban Canal
▪ Gothenburg Canal	▪ Thirty-Mile Canal
▪ Kearney Canal	▪ Western Canal
▪ Keith-Lincoln Canal	▪ Winters Creek Canal
▪ Lisco Canal	

Table 2: Canals used to divert flows during the 2011 recharge demonstration project.

The demonstration project diverted 141,911 acre-feet of water. The estimated amount of water purposefully recharged into the aquifer was 64,699 acre-feet, with 36,168 acre-feet of the recharge expected to reach the river as accretions within 50 years. The accretions to the river through time are shown in figure 1 and table 1. The general method used to estimate the recharge amount presupposed that: (1) a simple water balance equation would be used to estimate recharge as the difference between the amount of water diverted and the amount of water returned to the stream; (2) rainfall and evaporation were not considered to significantly impact the amount of water recharged; and (3) in the canals where the field office staff were not able to measure the return, a conservative estimate would be made.

In many ways, the groundwater recharge and flood mitigation demonstration project was a success. The project sponsors were able to work through the administrative requirements, implement the project in a timeframe that allowed for taking advantage of flood flows present at the time, and recharge a significant amount of water to the aquifer. A technical memo documenting the demonstration project in more detail is available on the Department's website at: http://dnr.nebraska.gov/iwm/conjunctive-management-toolbox.

Image 2: Photograph of a dry canal before the groundwater recharge demonstration project began.

Image 3: Photograph of a filled canal during the groundwater recharge demonstration project.

Conclusions

Conjunctive management projects, such as the one described above, are designed to provide managers with information necessary to determine how hydrologically connected surface and groundwater resources can be most efficiently and effectively put to use. As was outlined in *Water Matters,* No. 8, the recharge rate of aquifers, and the response time and accretion rates between hydrologically connected aquifers and streams, vary depending on local hydrological conditions. This project provided resource managers with the opportunity to more accurately quantify the hydrologic relationship between surface water flows, groundwater recharge, storage capacity, and accretion rates along the Upper Platte River.

Given the unpredictable nature of water availability, obtaining data such as that provided by the 2011 recharge demonstration project will remain a vital component of sound conjunctive management decision-making. While this *Water Matters* focused on the groundwater recharge of excess flows, the same principles apply to other sources of recharge water as well, such as water in surface water reservoirs and existing water rights that could be transferred for groundwater recharge use. Through water management planning, conjunctive management strategies help to ensure the availability and reliability of water supplies for future use.

Image 4: Photograph of a canal used during the groundwater recharge demonstration project.

Through water management planning, conjunctive management strategies help to ensure the availability and reliability of water supplies for future use.

Project Partners
NRDs
▪ Central Platte NRD
▪ North Platte NRD
▪ South Platte NRD
▪ Tri-Basin NRD
▪ Twin Platte NRD
Irrigation Districts
▪ Bridgeport Irrigation District
▪ Castle Rock Irrigation District
▪ Central Irrigation District
▪ Central Nebraska Public Power and Irrigation District
▪ Chimney Rock Irrigation District
▪ Cozad Canal Company
▪ Enterprise Irrigation District
▪ Farmers Irrigation District
▪ Keith-Lincoln County Irrigation District
▪ Lisco Irrigation District
▪ Minatare Canal Company
▪ Nebraska Public Power District
▪ Nine Mile Irrigation District
▪ Pathfinder Irrigation District
▪ Paxton-Hershey Water Company
▪ Platte Valley Irrigation District
▪ South Side Irrigation Company
▪ Suburban Irrigation District
▪ Thirty-Mile Canal Company
▪ Western Irrigation District
▪ Winters Creek Canal Company

Table 3: NRDs and irrigation districts that participated with the Department in the 2011 recharge demonstration project.

The theoretical concepts on which this project is based are described in more detail in *Water Matters*, No. 8.

Nebraska Department of Natural Resources

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MANAGEMENT

ERA OF WATER PLANNING AND POLICY DEVELOPMENT

1981
Legislature authorizes a State Water Planning and Review process.

1984
Legislature authorizes instream flow appropriations to protect recreation, fish and wildlife.

Legislature requires Natural Resources Districts to prepare local groundwater management plans.

1986
Legislature passes bills to implement groundwater quality protections, including expanding water quality authorities.

1991
Legislature requires Natural Resources Districts to expand their management plans to include protection of groundwater quality.

1993
Legislature enacts laws governing the use of pesticides.

1996
Legislature establishes integrated management of groundwater and surface water.

ERA OF COLLABORATIVE WATER PLANNING PROCESS IMPLEMENTATION

2000
Natural Resources Commission is merged with Department of Water Resources to create the present Department of Natural Resources.

2004
Legislature directs NRD/DNR collaboration of Integrated Water Management Plans to address surface water and groundwater as a single resource.

2010
Legislature allows voluntary Integrated Water Management Plans.

2014
First voluntary Integrated Water Management Plans adopted.

GROUNDWATER
Does not run off and is not taken up by plants, but soaks down into an aquifer.

INTERSTATE WATERS

Nebraska participates in six interstate water compacts, agreements, or court decrees, approved by participating state legislatures and Congress, or decreed by the United States Supreme Court. These compacts allocate water among states and often impact state water planning efforts. They are primarily administered by DNR with varying degrees of coordination and support from other state agencies and NRDs.

FEDERAL INVOLVEMENT

Nebraska's administration of water is affected by federal regulations and impacted by the involvement of federal agencies. Three of the most significant regulations are:

- The Clean Water Act (1972) is the principal law governing pollution of the nation's surface waters (includes water standards, enforcement, and expanded federal jurisdiction, but maintains state responsibility for day-to-day implementation of the law).
- The Endangered Species Act (1973) provides for the conservation of threatened and endangered plants and animals and their habitats.
- The Safe Drinking Water Act (1974) regulates the public drinking water supply.

SUPPORTING ROLES

Many state and federal agencies, and the NRDs, make funding available through a variety of programs. Two additional state bodies have roles that support, but do not specifically manage or regulate water:

University of Nebraska-Lincoln Conservation and Survey Division
- Collects, manages, and distributes groundwater data.
- Provides information and assistance regarding groundwater supplies and contamination.
- Conducts scientific studies involving water.

Natural Resources Commission
- State commission charged with helping to conserve, protect, and use the water and related land resources of the state through the oversight of seven state aid programs.

CONTACT US

The Nebraska Department of Natural Resources is proud to support Nebraska's water users and work on behalf of the citizens. Please feel free to contact us at any time.

Nebraska Department of Natural Resources

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Revised 04/2015

WATER MANAGEMENT IN NEBRASKA

Managing Water the Nebraska Way

HISTORY OF WATER

ERA OF INDEPENDENT MANAGEMENT OF GROUNDWATER AND SURFACE WATERS

1895
Surface water rights are assigned according to doctrine of prior appropriation (first in time, first in right).

1920
Nebraska constitution is amended to recognize the public interest in the use of water.

1933
Correlative use (shared use) doctrine is adopted for groundwater established through Nebraska Supreme Court ruling.

1943
Nebraska enters into Republican River Compact with Kansas and Colorado. Today, this is just one of six decrees (allocating water across multiple states).

1967
Legislature directs state Soil and Water Conservation Commission to prepare a State Water Plan.

1968-71
First portions of the State Water Plan are published.

1971
Legislature passes Nebraska Environmental Protection Act and creates the Nebraska Department of Environmental Control (now Environmental Quality).

1972
Legislature creates Natural Resources Districts as multipurpose, locally elected management bodies.

1975
Legislature directs primary responsibility for regulating groundwater to Natural Resources Districts.

Legislature prohibits state agencies from taking actions that jeopardize endangered species or their critical habitat.

1976
Legislature passes standards complementary to the National Safe Drinking Water Act.

1978
At request of Legislature, Natural Resources Commission and other state agencies issue a policy statement and workplan which recommends replacing the State Water Plan with a State Water Planning and Review process.

SURFACE WATER
Comprises all rivers and streams, lakes and reservoirs, or any other water that is on the Earth's surface.

Water management in Nebraska, like in many other states, involves a complex system of rules and management authorities. The responsibilities for water management tend to be determined by type of management (quantity or quality) and type of water (surface or ground), resulting in four quadrants of responsibility (below).

Water has defined Nebraska, from its naming (derived from the Otoe-Missouria and Omaha tribes' names for the Platte River meaning *flat water*), to its modern dependence on water for irrigation, power, recreation, fish and wildlife, and domestic use.

Over the years, Nebraska has developed a variety of administrative structures and processes to manage water uses and supplies. During its first century, Nebraska relied on a largely centralized approach to surface water management, and a separate locally based approach for groundwater management. In the 1970s, after a decade of attempting to develop "a blueprint for total development of the state's water that would serve for generations," Nebraska's water managers realized that "published plans frequently become outdated rapidly, and some serve only to collect dust after a short time."* Rather, they envisioned water planning as a "continuous process that would provide flexible guides for future decisions" and suggested elimination of "a State Water Plan and [to instead] concentrate on the Process." What followed was a series of policy and water right studies that evaluated numerous water issues including surface water rights, groundwater management, water use efficiency, instream flows, and the integrated management of surface water and groundwater. Subsequently, many of the recommendations from these studies were implemented.

In 1981 the Legislature assigned the Nebraska Department of Natural Resources overall coordination and other specific roles in water management and regulation. State agencies and local Natural Resource Districts were assigned other specific responsibilities for water management and regulation. In 2004, the Legislature established a collaborative state and local process that, for the first time, recognized the inter-connectivity of groundwater and surface water. Nebraska's structure has become a decentralized process that integrates groundwater and surface water management and regulatory processes locally and statewide.

WATER MANAGEMENT AND REGULATORY ROLES

*Natural Resources Commission Report to the Legislature and Governor, 1978

DNR — Department of Natural Resources

- Responsible for permitting surface water, rights for storage, irrigation, power, manufacturing, instream flows, and other beneficial uses.
- Coordinates the annual state water planning and review process (provide policy information, provide intergovernmental coordination, maintain data, enable planning and designing of projects and undertake planning activities).
- Issues permits for surface water, instream use, water storage, induced groundwater recharge for public water suppliers, and diversions by certain groundwater irrigation wells.
- Registers wells and delineates hydrologically connected aquifers on streams and rivers.
- Regulates the construction, operation, and maintenance of dams.
- Identifies and delineates floodplains and provides related assistance and coordination.
- Administers interstate water compacts, decrees, and agreements.
- Partners with NRDs to develop and manage Integrated Water Plans.

NRD — Natural Resources Districts (23 districts cover Nebraska)

- Partners with DNR to develop Integrated Water Plans.
- Maintains district plans and implements projects to protect groundwater and surface water quality and quantity.
- Partners with other agencies to develop multi-district river basin water management plans.
- Maintains district rules and regulations to deal with groundwater contamination, shortages or user conflicts, including groundwater well permitting, allocations, flowmeters, usage reporting, well moratoriums, irrigated acre expansion, and transfers.
- Receives applications and issues permits for chemigation (fertilizers/pesticides applied to land or crops in or with water) and inspects safety equipment on chemigation systems.
- Utilizes floodplain management measures to help protect people and property from flood damage.
- May hold a surface water right for instream flows.

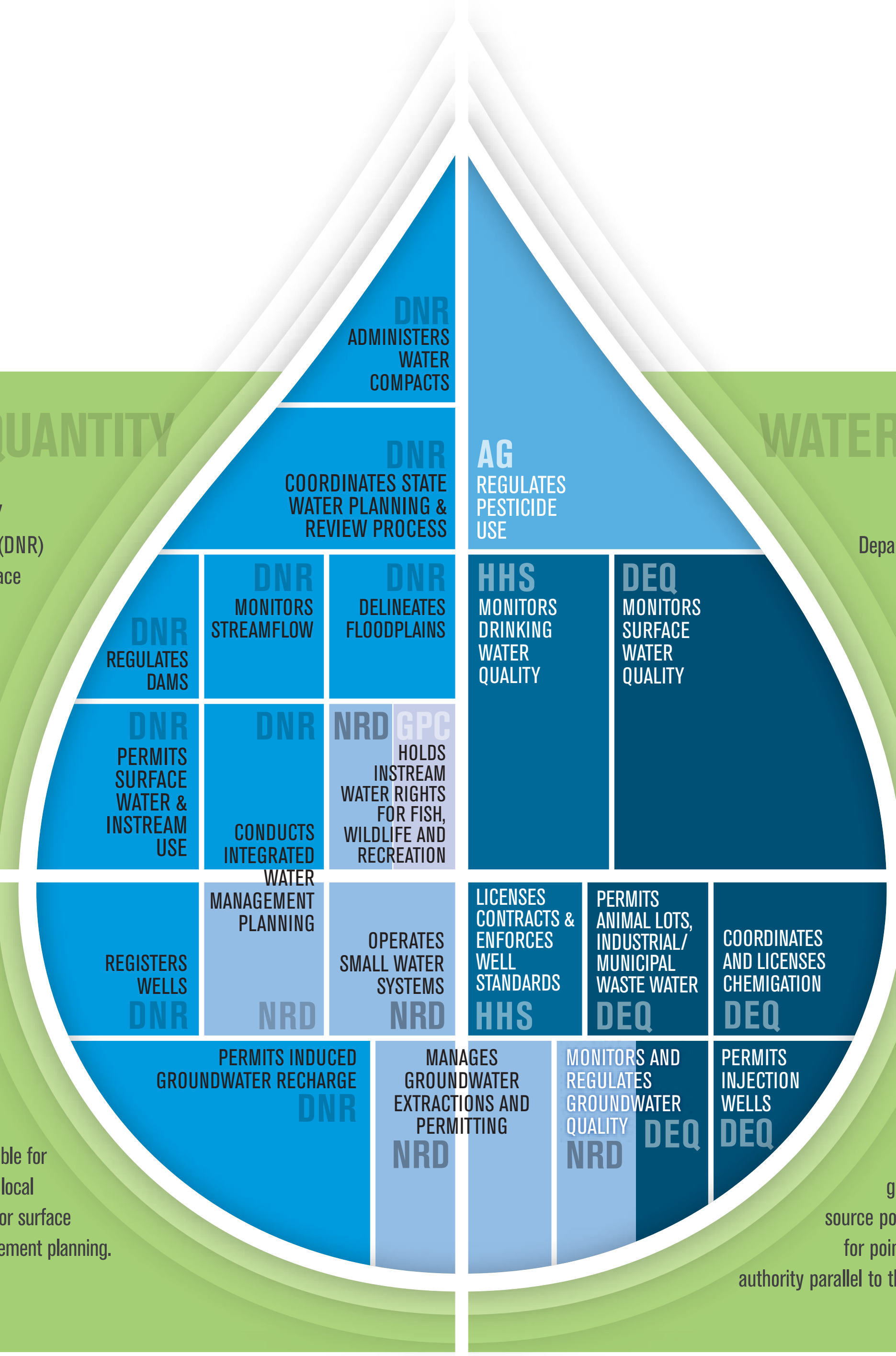
WATER QUANTITY

SURFACE WATER QUANTITY

Department of Natural Resources (DNR) has primary responsibility for surface water quantity. DNR and Natural Resources Districts (NRDs) are jointly responsible for surface and groundwater integrated management planning.

GROUNDWATER QUANTITY

The organizations primarily responsible for groundwater quantity are DNR and local NRDs. They are jointly responsible for surface and groundwater integrated management planning.



WATER QUALITY

SURFACE WATER QUALITY

Department of Environmental Quality (DEQ) has primary responsibility for surface water quality. Other agencies have responsibility within specific areas.

SURFACE WATER

GROUND-WATER

GROUNDWATER QUALITY

NRDs have primary responsibility for groundwater quality related to nonpoint source pollution. DEQ has primary responsibility for point source pollution of groundwater and authority parallel to the NRDs for nonpoint source pollution.

AG — Department of Agriculture

- Leads on issues relating to pesticides and water quality. Develops and implements state management plans for the prevention, evaluation and mitigation of occurrences of pesticides, or pesticide breakdown products, in groundwater and surface water.
- Regulates the distribution, storage, and use of all pesticides, and certifies and licenses pesticide applicators.
- Manages the Nebraska Buffer Strip Program for cropland adjacent to perennial and seasonal streams, ponds, and wetlands.

HHS — Department of Health and Human Services

- Assures drinking water quality through testing of public water systems and water wells.
- Licenses well and pump installation contractors.
- Enforces water well construction standards to protect groundwater quality.

GPC — Game and Parks Commission

- Ensures that water resource projects and programs consider and provide for fish and wildlife resources and the habitats that support them.
- May hold a surface water right for instream flows.

DEQ — Department of Environmental Quality

- Conducts surface water quality sampling in lakes, streams, and rivers.
- Conducts groundwater quality monitoring, review, and studies.
- Makes Clean Water Act impairment declarations.
- Coordinates chemigation programs and issues applicator certifications.
- Leads groundwater pollution remediation.
- Assists public water suppliers to prevent contamination.
- Issues permits for: injection wells; Concentrated Animal Feeding Operations (CAFO or AFO); and treatment and discharge of industrial and municipal wastewater and stormwater.