Memo

Date:	Monday, October 02, 2017
Project:	Lower Platte River Basin Water Management Plan
To:	Lower Platte River Basin Coalition
From:	HDR Team
Subject:	Conjunctive Management Opportunities for the Lower Platte River Basin Water Management Plan

1.0 Introduction and Background

The Lower Platte River Basin Coalition (Coalition) included a separate task focused on conjunctive management opportunities within its original Request for Proposal (RFP) for services related the development of a basin water management plan. The steps identified under this task were further refined in the Scope of Services developed by the Coalition and the consulting team, as outlined under Task 400 of that document. This Technical Memorandum summarizes the work conducted for the Coalition on conjunctive management opportunities during the course of this project.

Under the original RFP, the consulting team was tasked with leading one workshop to explain to, and discuss with, Coalition members both the water banking system and conjunctive management opportunities. In subsequent dialogue with Coalition members, it was determined that the complexity of the issues involved and the need for greater input from Coalition stakeholders called for water banking and conjunctive management discussions beyond the single workshop that was originally scheduled. In addition to a preview workshop presentation to the Technical Committee in Ord on February 10, 2015, a conference call with Technical Committee members was held on February 27, 2015, to discuss potential projects within each Natural Resources District (NRD) that had been studied or considered in the past, or that had otherwise been identified. Water banking and conjunctive management were discussed in three larger workshops in Columbus on March 10, July 20, and November 17, 2015, and three smaller breakout workshops for the Platte, Elkhorn, and Loup Basins on October 14, October 19, and October 21, 2015, respectively.

Information on conjunctive management opportunities was presented to both the Technical and Management Committees multiple times over the course of the project. In addition, the three larger workshop presentations were made available as pdf documents via the Coalition’s website. Other materials concerning conjunctive management opportunities were made available to participants of the breakout workshops, and to attendees of the various Technical and Management Committee meetings.

2.0 Conjunctive Management Background

Conjunctive management typically refers to the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various water needs.[1] Surface water and groundwater resources typically differ significantly in their availability, quality, management needs, and development and use costs. Managing both surface water and groundwater resources together, rather than in isolation, allows water managers to use the advantages of both resources for maximum benefit.

Conjunctive management thus involves the efficient use of both resources through the planned and managed operation of a groundwater basin and through a surface water storage system or conveyance infrastructure, or both. Water is stored in the groundwater basin for later and planned use by intentionally recharging the basin when excess surface water supply is available, such as during years of above-average surface water supply.

The necessity and benefit of conjunctive water management are apparent when groundwater and surface water are hydraulically connected. Well-planned conjunctive management can not only increase the reliability and the overall amount of water supply in a region, but also provide other benefits such as flood management, environmental water use, and water quality improvement. Greater benefit can usually be achieved when conjunctive water management is applied to multiple regions or statewide. Examples of conjunctive water management projects in the western United States include the following:

- Tamarack Project, Northeastern Colorado[2] – The Tamarack project in northeastern Colorado is a conjunctive management project that intentionally recharges South Platte River flows during low demand periods (October to March). Recharged flows return to augment South Platte River flows during higher demand periods (April to September), allowing junior groundwater users to irrigate without impacting senior surface water appropriations.

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1 J.J. Coe provides following definition: "Conjunctive use of surface and groundwater can be defined as the management of surface and groundwater resources in a coordinated operation to the end that the total yield of the system over a period of years exceeds the sum of the yields of the separate components of the system resulting from an uncoordinated system." "Conjunctive Use – Advantages, Constraints, and Examples," *Journal of Irrigation and Drainage Engineering*, 116, 3, pp 427-443, 1990.

2 Platte River Recovery Implementation Program, Attachment 5 – Section 3, *Colorado's Initial Water Project (Tamarack I)*, 2006.

- Tacoma, Washington[3] – The Green River is the principal water source for the City of Tacoma and typically requires minimal treatment. Seasonally, the Green River has periods of excessive turbidity, typically during the spring snowmelt runoff. During this time, the City augments the water supply with groundwater, blending the Green River and groundwater to lower turbidity to an acceptable level without addition of supplemental treatment processes.

- Phoenix, Arizona[4] – The metropolitan area of Phoenix conjunctively manages multiple sources—surface water, groundwater, imported water, artificial recharge, and reclaimed wastewater—to meet historical agricultural demands and the growing municipal and industrial needs.

In addition to these examples, there are numerous examples from the Upper Platte River and Republican River basins in Nebraska where conjunctive management projects have been employed by NRDs and the Nebraska Department of Natural Resources to offset depletive effects of use, to augment surface water flows, and to increase groundwater storage. These projects typically involve 1) diversion or capture of surface water; 2) storage or recharge of flows captured, or both; and 3) use of water, which may include management of return flows.

A sustainable conjunctive water management program consists of several components, including investigating the groundwater aquifer characteristics, estimating surface water and groundwater responses, and appropriate monitoring of groundwater level and quality. In addition, reliable institutional systems for ensuring environmental and regulatory compliance, providing long-term system maintenance, and managing contractual and legal features of the program are critical to sustainability.

2.1 Diversion or Capture of Surface Water

Typically, diversion or capture of surface water for groundwater recharge or flow augmentation projects is accomplished using existing storage or diversion structures, or both, or using newly constructed structures built as part of the project. Shallow alluvial wells immediately adjacent to the river can also be used to capture surface water flows. The primary operational characteristic of the proposed project as it relates to available water supply is the duration of the diversion/capture season.

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3 U.S. Army Corps of Engineers-Hydrologic Engineering Center, *Survey of Conjunctive Use and Artificial Recharge Activity in the United States*, 1984.

4 Arizona Department of Water Resources, *Third Management Plan for Phoenix Active Management Area 2000-2010,* 1999.

Projects that capture excess flows generally are considered a new use and require a new surface water appropriation. To determine the anticipated duration of the diversion/capture season for the project, the following must be considered: the use and diversion season restrictions of the appropriation, the availability of water as this new appropriation is typically junior to existing uses, and increased operation and maintenance for the project if the diversion/capture season is extended.

The HDR team identified and analyzed excess surface and groundwater volumes and locations in each of the three sub-basins of the Lower Platte Basin (that is, the Loup, Elkhorn, and Lower Platte Rivers) to evaluate the historic quantity of water in the Lower Platte River Basin in excess of the state protected flows in the Platte River. Because the basin accounting is performed on a seasonal basis, the excess flow analysis is useful in determining the location, duration of excess flows, and frequency of excess flows on a monthly time-step when evaluating the volume of water available for capture in support of potential conjunctive management projects. The description and results of this analysis are included in Appendix F – Excess Flow.

2.2 Storage/Recharge Facilities

The required size of the storage/recharge facilities can be approximated using estimated infiltration rates and volume of water available for capture/recharge. The computed areal extent should be adjusted for contingencies such as related infrastructure and periodic maintenance to estimate the land acquisition required for a project. Multiple storage/recharge facilities provide flexibility in the operation of the project and redundancy in case of unforeseen maintenance issues or the availability of larger volumes of water.

Existing infrastructure in the project vicinity should be inventoried to identify opportunities for using existing facilities to the extent possible, in addition to identifying potential constraints. Relevant infrastructure includes the following:

- Existing conveyance facilities, reuse or storage pits, and adjacent wells that could be used in the configuration of the groundwater recharge project. Typically, this information can be gathered from facility operations, from aerial and topographic mapping, and from site visits.
- Roads, irrigation pivots, parcel ownership boundaries, power lines, and utilities that may constrain siting of the storage/recharge facilities.
- Road and railroad embankments, houses and building sites, and lowland meadows or agricultural fields that may be susceptible to high groundwater tables.

2.3 Existing Uses, Planned Uses, and Management of Return Flows

Existing water uses may stay the same, increase, or be reduced. Planned uses could include uses such as irrigation, industrial, municipal, and hydropower, depending on the project goals. In many projects, flows of surface water and groundwater to the river are an important component of the project goals. Return flows to the river can be actively or passively managed, with the method employed largely dependent on the project goals. Active management generally includes recovery through pumping of groundwater or release of surface water from storage directly to the river, and is effective in meeting flow needs at specific times for specific durations. Passive management uses groundwater return flows as baseflow accretions to the river and is typically used to meet annual or long-term flow targets.

3.0 Conjunctive Management Opportunities

Technical Committee members provided information on potential conjunctive management opportunities within each NRD that had been studied or considered in the past, or that had otherwise been identified during the February 27, 2015, teleconference and subsequent discussions. Identified opportunities for each NRD are as follows:

1. Lower Loup NRD
    a. Sherman Reservoir (storage repurposing)
    b. Existing irrigation canals (retime flows)
    c. Sargent Irrigation District/Milburn Dam (canal recharge project)
    d. Canals downstream of Davis Creek Reservoir (recharge late season reservoir drawdown)
    e. >100 acres new storage structures (capture stormwater for groundwater recharge/retiming)
    f. Twin Loups Irrigation District groundwater mound (change all or a portion of project lands from surface water supply to groundwater or co-mingled source)
    g. Drop structures in drainage ditches (encourage recharge of return/runoff flows)
    h. Plum Creek below Loup Canal diversion (augmentation project; some preliminary work has been done)

2. Upper Elkhorn NRD
    a. Department of Water Resources (predecessor of NeDNR) 1960s study on Cedar Creek project near Oakdale (new storage reservoir)

3. Lower Elkhorn NRD
    a. Battle Creek Reservoir (new multipurpose reservoir)
    b. 1990s study on Butterfly Creek (new storage reservoir south of Stanton)

   c. 4 to 5 sites currently being investigated as part of Integrated Management Plan process (new storage reservoir)
   d. Existing storage reservoirs (rehabilitation/repurposing)
   e. Maple Creek Reservoir (new multipurpose reservoir)
   f. Holt Creek (grade stabilization/check dams to bring grade up to encourage recharge and prevent lowering of groundwater table due to stream incision)

4. Lower Platte North NRD
   a. Octavia Reservoir (storage and retiming Platte River water)
   b. Todd Valley (recharge project)
   c. Potential sites forthcoming as part of individual IMP process (recharge/reservoir)

5. Papio Missouri River NRD
   a. Bell Creek Reservoir above Highway 91 (storage and retiming of Bell Creek flows)
   b. Western Sarpy (redesign drainage ditches with storage at lower end using check structures for intentional recharge)

6. Lower Platte South NRD
   a. Use of alternative aquifers – Dakota or bedrock aquifer (streamflow augmentation from non-hydrologically connected aquifers)
   b. Augmentation well fields (streamflow augmentation)
   c. Enhanced runoff recharge (capture and recharge of watershed runoff)

7. Upper Loup NRD
   a. Mullen Dam (new storage reservoir)

4.0 Conjunctive Management Project Evaluation

Following the initial identification and discussion of conjunctive management opportunities (see Section 3.0), several were identified as representative of typical projects that may be implemented across the Lower Platte Basin. These representative projects were evaluated conceptually to illustrate potential benefits and considerations associated with these types of projects. These evaluations are summarized in the following sections.

4.1 Sargent Canal Recharge Project

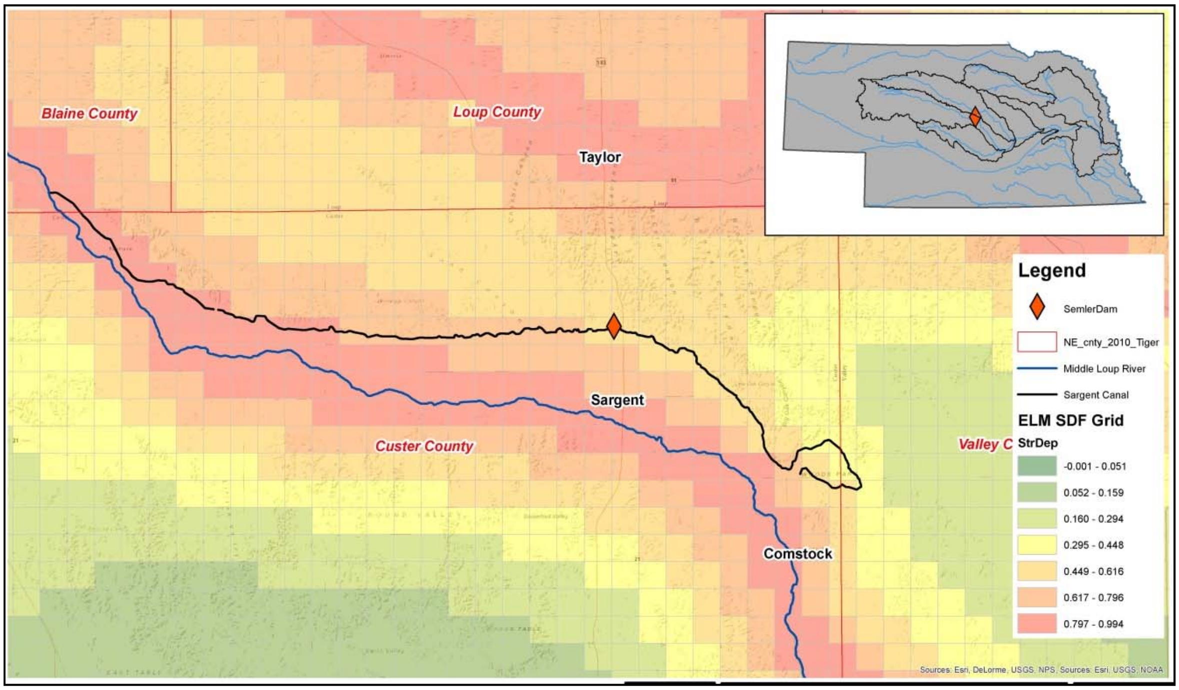
The Sargent Canal Recharge Project would use the existing Milburn Diversion Dam on the Middle Loup River and the Sargent Canal Irrigation District system. The purpose of the Sargent Canal Recharge Project is to retime flows during the non-peak season to be available in the peak season by diverting excess flows into the existing Sargent Canal during the months of April, May, October, and November. Return flows will passively accrete to the Middle Loup River throughout the year and will be available for use. This example is based on the Sargent Canal Irrigation District system, but there are multiple surface water projects on both the Middle Loup River and North Loup River that could function in a similar manner to retime flows in the system.

Using the linear canal as the only recharge facility and its daily seepage capacity of approximately 60 cubic feet per second (cfs), estimated long-term baseflow accretions could average in excess of 5,000 acre-feet (AF) annually. Semlar Dam and additional recharge pits could be used to increase the recharge capacity and, as a result, the volume of accretions to the Middle Loup River by allowing the retiming of a larger volume of excess flows. Using a diversion rate to Sargent Canal of 235 cfs to divert excess flows during the shoulder months and storing in Semlar Dam and recharge pits along the canal would result in average annual project accretion benefits that exceed 20,000 AF.

Potential constraints and considerations include third party impacts due to elevated groundwater elevations, coordination with annual canal maintenance activities, and existing operations and agreements amongst existing surface water irrigation districts on the Middle Loup River that may affect the allowable diversion season.

Project costs would include the operation and maintenance costs associated with Sargent Canal and the lease agreement to use the Sargent Canal Irrigation District’s facilities. Project costs for adding recharge pits would include site grading and land acquisition.

Figure 1: Sargent Canal System



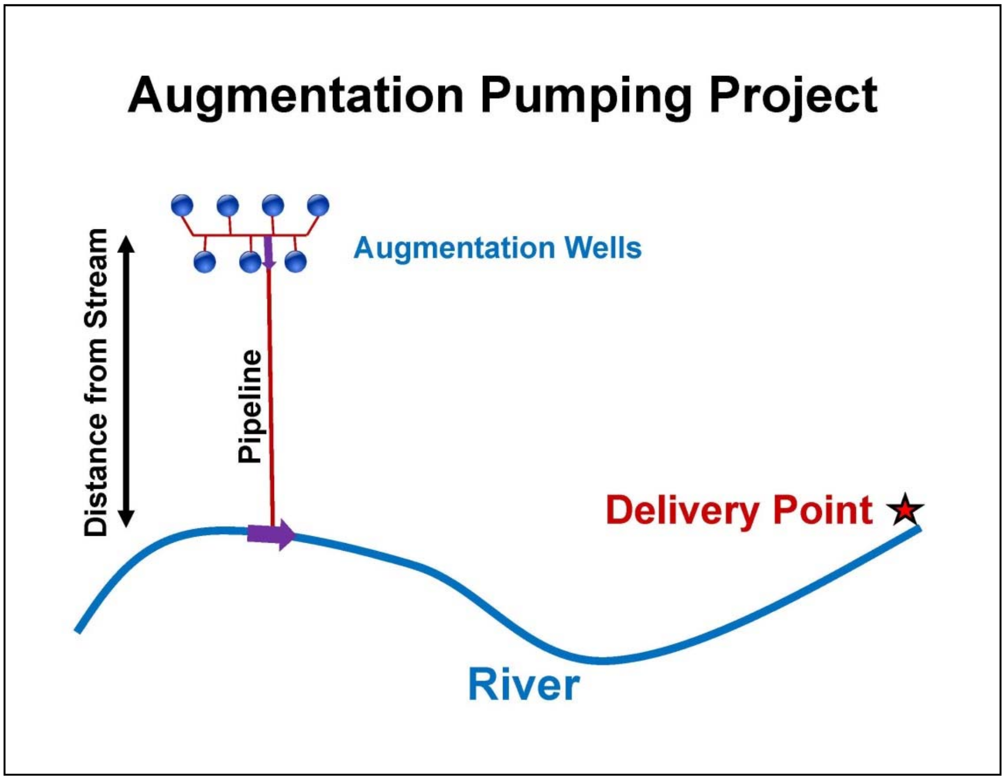
4.2 Well Field Augmentation Project

The purpose of a well field augmentation project would be to develop a well field at a location with significant, and accessible, groundwater supplies, preferably at a considerable distance from the stream (low connectivity). New wells should draw water primarily from the aquifer so as not to rely on induced recharge from the nearby surface water sources. This would require that distances of the new wells be given priority to be located far from the river. Ideally, new wells would be spread out to minimize interference with neighboring wells. The well field could be used to pump water on demand that could be delivered to augment surface water flows, primarily for short durations during times of low flows. While specific sites were not investigated in detail, potential locations for a well field augmentation project include the area of the groundwater mound near the Twin Loups project in the Loup River basin; in the alluvial aquifers of the Platte, Loup, and Elkhorn River systems; and in the Todd Valley in the Lower Platte River area. The pumping activities at the former Nebraska Ordinance Plant near Mead were also looked at as a potential continuous augmentation source. Typical discharges from the remediation project are in the range of 5 cfs, however, and are not considered significant enough to mitigate low flow conditions in the Platte River.

Potential constraints and considerations include third party impacts due to well field pumping, well interference, discharge capacity of the receiving tributary (should one be used in lieu of direct conveyance to the river), and managing depletive effects of well field pumping so as not to exacerbate low flow conditions.

Project costs would include the development of the wells and well field infrastructure, as well as conveyance to the receiving stream.

Figure 2: Schematic of an Augmentation Pumping Project



4.3 Sherman Storage Reallocation and Farwell Canal Recharge Project

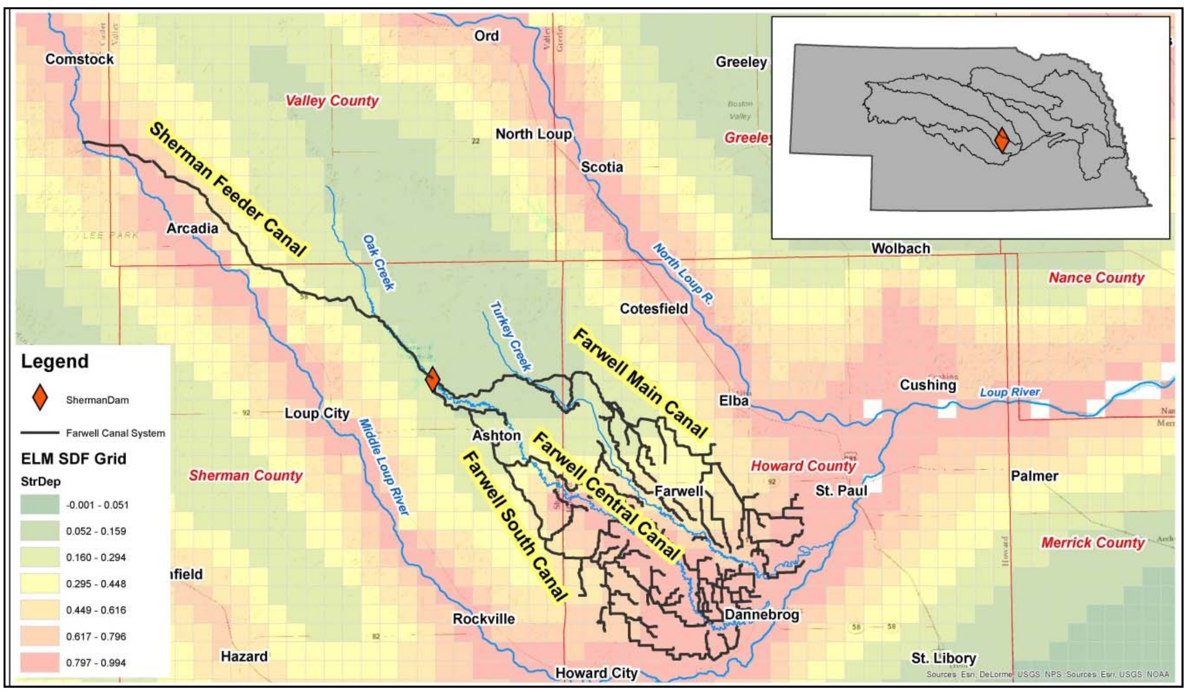
The Sherman Storage Reallocation and Farwell Canal Recharge Project would reallocate a portion of stored water in Sherman Reservoir to be managed for retiming and augmenting stream flows. Reallocating storage in Sherman Reservoir could provide benefits in two ways: 1) the stored water could be actively managed to augment flows through releases from reservoir storage; and 2) the stored water could be released during the non-irrigation season and intentionally recharged using the existing Farwell Irrigation District canal system. The additional groundwater recharge could also be used as a supplemental source to Farwell Irrigation District surface water irrigators to supplement water supplies for irrigation. While this effort focused on Sherman Reservoir, a similar approach could be used on the Davis Creek Reservoir.

Reallocating or repurposing the upper 3 to 4 feet of Sherman Reservoir’s normal storage pool would provide approximately 8,000 to 10,000 AF of water annually for release or intentional recharge purposes. Active releases would by 100 percent benefit to stream flow at the point of discharge, with benefits decreasing downstream as conveyance losses are incurred. Depending on the canal facilities used for intentional recharge, the degree of connection with the aquifer varies (see Figure 3), but a reasonable estimate of 50 percent return of recharge annually as baseflow accretion is reasonable in the long term. Loss estimates of 55 to 80 percent may occur as flows are conveyed through the system to the confluence of the Missouri River.

Potential constraints and considerations include obtaining a storage agreement with owners of Sherman Dam, impacts on Farwell Irrigation District users, potential high groundwater tables in areas of intentional recharge, and protection of releases from use via conveyance appropriation from the Nebraska Department of Natural Resources.

Project costs would primarily include the purchase/lease of storage water agreement with the owner and the compensatory elements of the agreement. In addition, operation and maintenance costs would occur to mitigate any impacts on the Farwell Irrigation District infrastructure of the intentional recharge activities.

Figure 3: Sherman Reservoir and Farwell Canal System



4.4 Skull Creek Reservoir

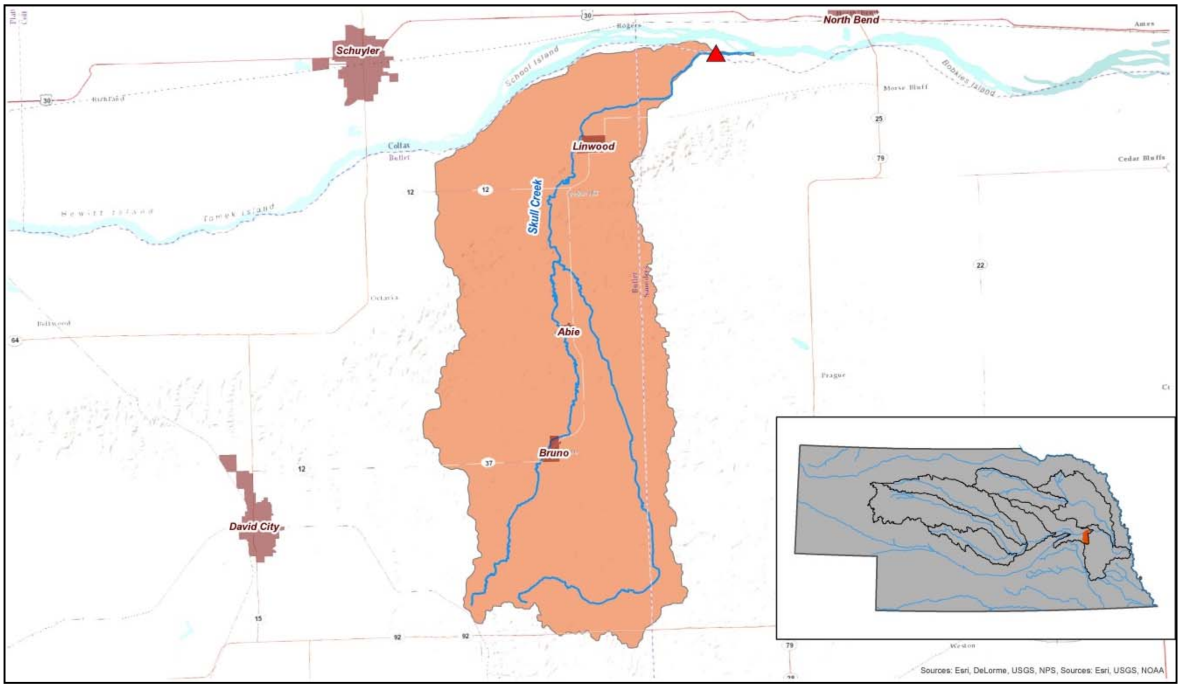
Located in the Lower Platte North NRD near Linwood, the purpose of the Skull Creek Dam Project is to store and retime flows, which are primarily available during the non-peak season, to be available on demand for release to the Platte River just upstream of North Bend. The dam could also be designed to offer multiple benefits to the public, including recreation, flood control, and grade stabilization. The Skull Creek reservoir site has been identified in past studies as a potential flood mitigation project. The estimated storage volume of water available for active management is 2,000 AF annually. The source of the water would be runoff from the contributing watershed, available to be stored when downstream flows are being met and the new storage appropriation would be in priority. The 2,000 AF of reservoir storage would be able to augment surface flows at a release rate of 140 cfs for 7 days to mitigate low flow conditions. The reservoir could be designed to provide carryover storage to capitalize on wet years and years when releases are not required. This would allow additional storage to be available in excess of the 2,000 AF and would allow an increase in either the release rate or duration of releases.

While this project would result in a smaller volume of release than the Sherman Reservoir example provided in Section 4.3, the Skull Creek Dam Project is in much closer proximity to Lower Platte, and loss rates of less than 50 percent are anticipated as flows are conveyed through the system to the confluence with the Missouri River. Other potential project benefits include recreation, groundwater recharge, flood control, irrigation, fish and wildlife habitat, and habitat restoration.

Potential constraints and considerations include third party impacts due to increased groundwater elevations in the reservoir vicinity, acquisition of land for the reservoir, environmental permitting constraints, and managing the reservoir to fulfill multiple project purposes (if necessary).

Project costs would include engineering costs, site construction, land acquisition, and annual operations and maintenance.

Figure 4: Skull Creek Watershed



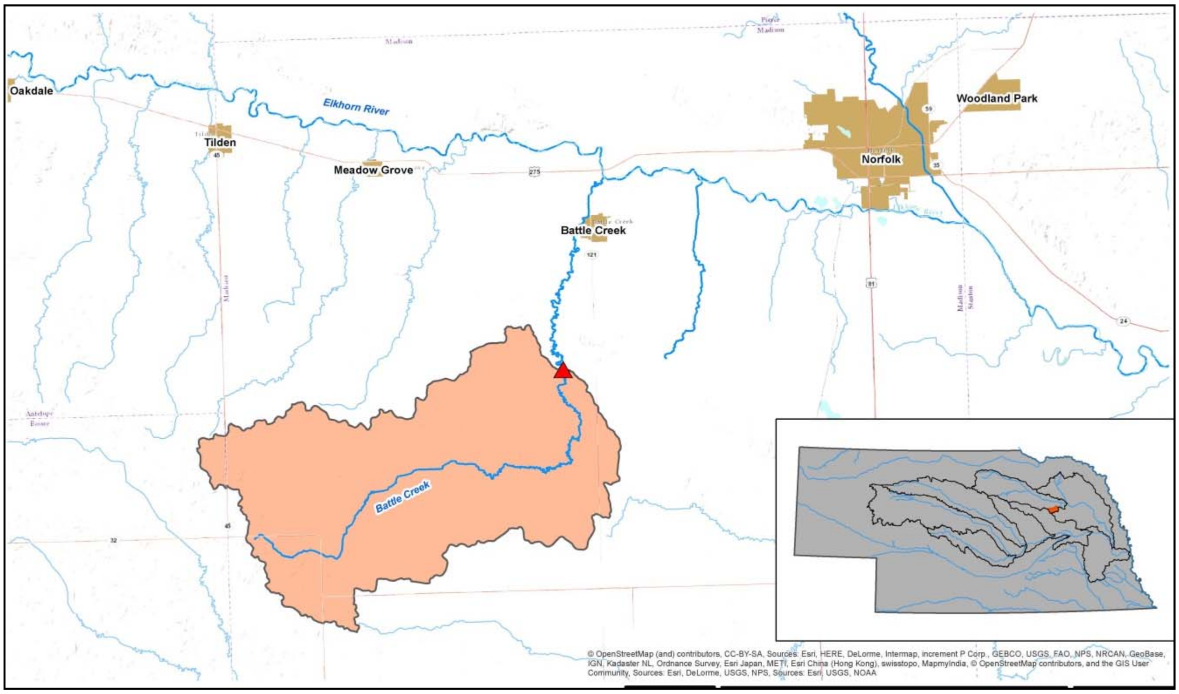
4.5 Battle Creek Reservoir

Located in the Lower Elkhorn NRD southwest of Battle Creek, the purpose of the Battle Creek Reservoir Project is to recharge groundwater and retime flows during the non-peak season to be available in the peak season to the Elkhorn River. Along with these benefits, the dam could offer recreation, flood control, and environmental benefits. The approximate permanent pool would be 1,200 acres, with an estimated seepage rate of 6,100 AF per year that would augment baseflow accretions to the Elkhorn River. Other potential project benefits include recreation, flood control, fish and wildlife habitat, and habitat restoration.

Potential constraints and considerations include third party impacts due to increased groundwater elevations in the reservoir vicinity, acquisition of land for the reservoir, environmental permitting constraints, and managing the reservoir to fulfill multiple project purposes (if necessary).

Project costs would include site construction, land acquisition, and operations and maintenance.

Figure 5: Battle Creek Watershed



4.6 Dwight-Valparaiso-Brainard Additional Supply

Located in the Lower Platte South NRD, the purpose of the Dwight-Valparaiso-Brainard Project would be to capture runoff to recharge the groundwater aquifer. This area has been designated as a special management area of the Lower Platte North NRD where declining water levels have been a recurring problem, particularly in periods of drought where increased irrigation pumping has resulted in well interference complaints and domestic well impacts. Studies conducted by the Lower Platte South NRD have shown the average mining of the aquifer to be approximately 4,400 AF per year over the approximately 150 square mile area. An allocation of 21 acre-inches over 3 years, with a maximum 9 acre-inch use in any 1 year on all certified irrigated acres, has been implemented in the area. Crop irrigation requirements in the area average 7 to 8 inches from statewide net corn crop irrigation requirements estimates. Average annual runoff from the U.S. Geological Survey (USGS) Hydrologic Atlas 710 is estimated as 3 to 4 inches in the management area for the period 1951 to 1980. It is likely that land treatment practices have been implemented post-1980 that reduce the estimated runoff from the USGS study.

Based on the area of 150 square miles, approximately 0.6 inch of additional recharge annually would offset the 4,400 AF annual depletion of the aquifer. Land management practices such as distributed small detention cell/recharge basins, buffered waterways, modification of road crossing structures to detain flows and enhance recharge, and terraces could be implemented to augment existing conservation practices and enhance recharge to mitigate the depletive effects of pumping over the long term. These activities would work in concert with the allocation efforts initially, and potentially in lieu of allocations at some point in the future based on success of the recharge efforts.

In addition to the enhanced recharge opportunities, a monitoring plan using transducers throughout the management area could be implemented, with appropriate action levels determined to more proactively manage aquifer levels and minimize well interference impacts.

Project costs would include site construction, land acquisition, and operations and maintenance, as well as monitoring activities. It is anticipated that cost-sharing agreements with landowners would be the primary means of implementation.

Figure 6: Dwight-Valparaiso-Brainard Special Management Area