Rainwater Basin Joint Venture Water Plan

A contribution to the

Rainwater Basin Joint Venture Implementation Plan

By the Rainwater Basin Joint Venture

Water Workgroup

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Appendices

Executive Summary

The Rainwater Basin Joint Venture (RWBJV) Water Plan was developed to increase ponded habitat across the Rainwater Basin (RWB) for wetland-dependent birds during migration. The 2013 revision of the RWBJV Implementation Plan recognized the importance of increasing ponded habitat on private wetlands enrolled in long-term conservation programs (e.g. Wetland Reserve Easements {WRE}) and on public wetlands owned and managed by the Nebraska Game and Parks Commission (NGPC) or the U.S. Fish and Wildlife Service (USFWS). Under average climatic conditions, the RWBJV's goal is to have 17,775 acres ponded during spring migration. At goal, that would equate to 12,060 acres of ponded habitat on public wetlands and 5,715 acres of ponded habitat on private wetlands enrolled in long-term conservation programs. This is equivalent to 45% of the total acres of public wetlands and private wetlands enrolled in long-term conservation programs. To achieve this ponding goal multiple strategies were developed:

- Strategic acquisition of public land roundouts or the use of floodage easements to mitigate impacts to adjacent private lands.
- Hydrologic improvements, including the filling of concentration/irrigation reuse pits and surface drains, and removal of culturally-accelerated sediment and fill.
- Off-site watershed restoration, to the extent possible, intended to maximize natural runoff to the wetlands by removing at least 75% of the irrigation reuse pits in the watersheds, with priority given to pits nearest the wetland and with the largest storage volumes.
- Re-contour waterways and add/or replace culverts and other road infrastructure to maximize the amount of water reaching the wetland.
- Use supplemental water deliveries (i.e., groundwater and surface water) to support timely ponding.
- Install necessary infrastructure (e.g., groundwater wells, buried pipelines, engines) to increase supplemental water deliveries to wetlands.
- Develop a reliable, long-term funding source that will support an expanded supplemental water delivery program.

Introduction

The Rainwater Basin Wetland Complex (RWB) in south-central Nebraska encompasses 6,100 square miles throughout 21 counties. Historically, the gently rolling topography of this region contained over 11,000 shallow playa wetlands covering over 204,000 acres, or approximately 5% of the landscape (Bishop and Vrtiska 2008). Playa wetlands are isolated wetlands not connected to natural drainages. Each wetland has a unique watershed that channels runoff from precipitation and snowmelt to the wetland at the terminus of the watershed (Smith 2003). Water levels of RWB playas tend to draw down partially or entirely during dry periods, and smaller wetlands may remain dry for months or years, depending on precipitation patterns (Gersib et al. 1990). Before agricultural development, the uplands surrounding these wetlands were dominated by tall-grass or mixed-grass prairie (Smith 2003).

The loess soils in the uplands adjacent to playa wetlands are highly productive. Due to their small size and ephemeral hydrology, playas in the RWB are relatively easy to drain, fill, and/or plow (Gersib et al. 1990). Today, the RWB landscape is dominated by row-crop agriculture. Nearly 70% of the RWB landscape is cultivated for agricultural production; 19% remains upland grasslands, less than 1% is playa wetlands with the remainder in other uses. The remaining 10% of the landscape is comprised of Riverine habitats found along the Blue Rivers and developed land including cities, roads, and farm steds. Only 40,000 acres, or 20%, of the historic RWB playa wetlands remain (Bishop and Vrtiska 2008, Raines et al. 1990, Schildman and Hurt 1984).

These few remaining wetlands continue to function at a limited capacity due to previous drainage attempts and watershed alterations. Past conversion attempts often included a combination of surface drains, fill material placed in the hydric soil footprint, construction of dikes, and excavation of concentration pits within the wetland and/or irrigation reuse pits in the watersheds. As a result of the adjacent uplands being cultivated, culturally-accelerated sedimentation into the wetland continues to reduce wetland function. In addition, irrigation reuse pits and road ditches within the watershed divert water and negatively impact hydrologic functions including the duration, magnitude, and frequency of ponding (Bishop and Grosse 2012, Bishop and Vrtiska 2008). As a result of these wetland and watershed alterations, conditions often exist that allow colonization by undesirable plant species (Kercher and Zedler 2004, Kercher et al. 2004, Kercher et al. 2007, LaGrange 2005, LaGrange et al. 2011).

Recent evaluations indicate a decline in ponding frequency and ponded area on many publically managed wetlands during spring migration (Drahota 2014a). Climatic changes (Uden 2012), sediment deposition (Daniel et al. 2015, Luo et al. 1997, Smith et al. 2011), and organic carbon accumulation (Daniels 2016) threaten future wetland function and habitat conditions across the Great Plains. Conservation partners continue to refine and improve conservation program delivery by focusing on reducing these impacts, implementing restoration practices that improve wetland function, and monitor habitat conditions to provide feedback about the success of these programs.

Importance of Rainwater Basin Wetlands

Despite the extensive wetland loss that has occurred in the RWB, this landscape remains a critical mid-latitude stopover area for migratory birds. At population levels outlined in the North American Waterfowl Management Plan (North American Waterfowl Management Plan [NAWMP] Committee 2012) an estimated 8.6 million waterfowl depend on the RWB each spring migration. This includes 50% of the mid-continent population of Mallards and 30% of the continental population of Northern Pintails. An estimated 500,000 shorebirds (RWBJV 2013b) also rely on the RWB during migration. Based on analysis of banding data, it is also expected that nearly the entire Wood Buffalo – Aransas population of the federally endangered Whooping Crane will use RWB wetlands at some point in their life (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005).

For wetland dependent migratory birds, spring migration is an energetically demanding period (Baldassarre and Bolen 2006, Newton 2008). In addition to maintaining body condition, individuals that accumulate sufficient lipid reserves that support migration completion in a timely fashion (LaGrange and Dinsmore 1988, Casady 2013, Drahota 2014*b*), and therefore have access to the best breeding areas, may be more productive (Anteau and Afton 2009, Devries et al. 2008). While waste corn comprises a significant portion of the diets of geese and some ducks in Nebraska during spring migration (Drahota et al. 2016, Pearse et al. 2010, Pearse et al. 2011*b*), corn lacks certain amino acids required for tissue maintenance and follicle development (Baldassarre and Bolen 2006, Krapu et al. 2004, Loesch and Kaminski 1989). Loesch and Kaminski (1989) and Reid et al. (1989) found that naturally occurring wetland plant seeds were a necessary component of duck diets to offset the protein and mineral deficiencies associated with agricultural food sources. In addition, common duck species that stage in the RWB predominantly consume wetland-derived energy sources (Drahota et al. 2016, RWBJV 2013*c,*). Furthermore, nearly 500,000 shorebirds rely on the plentiful invertebrate resources of stopover habitats in the RWB (Davis et al. 2005, Farmer and Parent 1999, Skagen and Knopf 1994). This highlights the importance of providing wetland-derived food resources for migratory birds.

Bishop and Vrtiska (2008) estimated that 2.6 million waterfowl, mostly ducks, stop in the RWB region during fall migration which typically extends from early August through the end of November. For the most part, waterfowl hunting seasons are scheduled to overlap with the fall migration period. The 2012 revision of the NAWMP emphasizes the need to increase waterfowl hunter numbers through retention and recruitment (NAWMP 2012). In recent decades, there has been a steep decline in hunter participation despite higher-than-average waterfowl numbers as well as liberal bag limits and season lengths. This trend ultimately results in fewer financial resources available for the conservation of waterfowl and their habitats (Vrtiska et al. 2013). In dry years, waterfowl hunting opportunities on public lands may be very limited. Providing ponded wetland habitats in the fall not only generates foraging resources for waterfowl to complete the southward migration and prepare for winter, but also increases the quantity and quality of hunting opportunities, which is an important component of hunter retention and recruitment.

Rainwater Basin Joint Venture

In 1991, the NAWMP Committee officially recognized the RWB as the eighth area in North America to merit Joint Venture status. The goal of the Rainwater Basin Joint Venture (RWBJV) is to restore and maintain sufficient wetland habitat in the RWB to assist in meeting population objectives identified in the NAWMP (RWBJV 2013*a*) and in the three other national bird plans (North American Landbird Conservation Plan [Rich et al. 2004], North American Waterbird Conservation Plan [Kushlan et al. 2002], and the United States Shorebird Conservation Plan [Brown et al. 2001]). A 15 member management board, comprised of federal agencies (n=3), landowners (n=4), local natural resources districts (n=3), non-government organizations (n=4), and state government (n=1) oversees the planning and conservation delivery activities of the RWBJV partnership. In 2013, the RWBJV Management Board adopted the revised Implementation Plan. This revised plan outlines the habitat objectives necessary to support the population objectives defined in the national plans. To achieve these habitat objectives, the management board works to find unique solutions to wetland conservation that are both effective and socially accepted.

The initial RWBJV Implementation Plan (Gersib et al. 1992) was solely focused on wetlands and adjacent upland buffers. The original goals were to protect 9,000 existing wetland acres and restore or create an additional 15,000 acres. As part of the 2013 Implementation Plan revision, a bio-energetics model was used to refine habitat objectives necessary to support the estimated 8.6 million waterfowl (RWBJV 2013*c*) and 500,000 shorebirds (RWBJV 2013*b*) that are predicted to use this region at population goals defined in the NAWMP (NAWMP 2012) and United States Shorebird Conservation Plan (Brown et al. 2001). These energetics models indicated that wetlands in the RWB would need to provide 4.4 billion kilocalories (kcals) of wetland-derived food resources for waterfowl (RWBJV 2013*a,* RWBJV 2013*c*) and 210 million kcals from invertebrates for shorebirds (RWBJV 2013*b*). Research conducted by Drahota and Reichart (2015) indicate that RWB wetlands provide ~74,000-298,000 kcals/acre of wetland-derived seed energy for each ponded acre on public land. If ponded, a single acre can provide 250 - 1,000 duck energy days (DEDs), or sufficient food to feed that many ducks for a single day. Yet ponding is highly variable and depends on precipitation, runoff, and soil conditions. Aerial surveys conducted by the USFWS suggest that pumped water can increase available ponded habitat by ~40% in average years and increase available forage by ~70% in dry springs (Drahota 2014a). Currently, pumping adds an additional ~1,400 acres of ponded water (Drahota 2014a), providing 103-417 million DEDs each spring. Therefore, in order to provide sufficient wetland habitat to meet these foraging objectives, the RWBJV developed strategies for both public and private lands that would result in a sufficient wetland base. In total, the wetland base to be protected and restored would be 62,000 acres (RWBJV 2013a). The Implementation Plan also sets a target of increasing the ponding frequency on these acres. Strategies for increasing ponding frequency included watershed restoration and use of groundwater and surface water deliveries to provide 27,900 acres of ponded habitat under average climatic conditions.

Rainwater Basin Joint Venture Conservation Targets

The RWBJV established conservation targets based on ten years of Annual Habitat Survey data. Each year the RWBJV conducts a survey to measure wetland ponding, called the Annual Habitat Survey. This survey is conducted utilizing color infrared aerial photography. From this imagery the ponded water and hydrophytes, or wetland dependent vegetation, are mapped. Data derived from this survey suggested that available habitat is split nearly evenly between public and private lands. Based on these findings, wetland habitat objectives (acres) were established whereby half of the habitat would be available on public lands and the other half available on private lands. Private lands habitat objectives were split among wetlands enrolled in long-term conservation programs ($\geq$ 30 years), short-term conservation programs ($\leq$ 10 years), and wetlands not enrolled in conservation programs. In addition to protection targets (i.e., acres of wetlands), targets for hydrologic restoration and ponding frequency were also established for the public wetlands and private wetlands enrolled in long-term conservation programs.

On public lands, the strategy is to acquire 7,900 acres of essential roundouts from willing sellers. Roundouts are those privately owned tracts of land that contain a portion of the wetland footprint already partially owned and managed by a subdivision of government. These tracts are prioritized based on the hydrologic restoration potential and increased management that could occur on the public areas if these tracts were part of the adjacent public property. If the strategy of acquiring 7,900 roundout acres is achieved, there will be approximately 26,800 public wetland acres managed by either the USFWS as Waterfowl Production Areas (WPAs) or the NGPC as Wildlife Management Areas (WMAs). After acquisition, wetland habitat will be restored to the fullest extent possible.

To meet the private lands, long-term conservation target, an additional 9,250 acres of privately owned wetlands will need to be enrolled in voluntary conservation programs. All wetlands enrolled in these programs will also have on-site hydrology restored to the fullest extent possible. To achieve this target, there will be 12,700 acres of restored wetlands enrolled in these programs.

To maximize desirable habitat conditions on public and private wetlands, grazing infrastructure will be established. This will include perimeter fences and livestock watering wells. If wetlands become dominated by undesirable (e.g., bulrush, cattail) or invasive species (e.g., purple loosestrife, reed canary grass), intense management treatments (e.g., mechanical, chemical) will be implemented to promote desirable vegetation communities (Drahota and Reichart 2015, RWBJV 2013*b*, RWBJV 2013*c*).

As part of the revised RWBJV Implementation Plan, Geographic Information System (GIS) data were analyzed to describe watersheds and the locations of irrigation reuse pits and concentration pits. As a result of this inventory, 874 pits were identified on private land in the watersheds of public wetlands. The analysis also indicated that 385 pits were located in the watersheds of wetlands enrolled in long-term conservation programs. Recognizing that not all private landowners would be interested in filling these pits, a minimum target was established to fill 656 pits in the watersheds of public wetlands and 289 pits in the watersheds of wetlands enrolled in long-term conservation programs. This target represents a 75% reduction in the number of pits in the watersheds of public and privately owned wetlands enrolled long-term conservation programs.

Beyond watershed restoration, the RWBJV also established a strategy to utilize supplemental water deliveries from high capacity groundwater wells and surface water diversions to maximize available ponded habitat. On the 95 publicly managed properties, there are 75 functional, high capacity groundwater wells that currently can be used to supplement ponded habitat when funding is available. It should be noted that USFWS WPAs have 31 groundwater wells that lack motors and are currently inoperable. In the RWBJV Implementation Plan, one of the strategies is to have 45% of the habitat base ponded during spring migration. This is approximately a 25% increase in ponding frequency above what is occurring now (Bishop and Grosse 2012, Drahota 2014a).

Although supplemental water deliveries are identified as a strategy, there are social realities that have to be considered beyond the primary reasons that the USFWS and NGPC supplement water. The primary reasons the agencies supplement water include: 1) provide habitat for migrating water birds, 2) provide areas for wildlife observation and waterfowl hunting, and 3) spread out the distribution of migrating birds. The following are some of the social considerations and process that agencies use to try to maximize the results of supplemental water deliveries.

Nebraska has a teal hunting season that opens in September, but there are factors to consider when pumping early. In September, hot weather can lead to significant water evaporation and plants that are still actively growing have a high rate of transpiration (water loss through growing plants). In most years, this makes pumping in early September inefficient, especially considering the low capacity of some of the pumps on public areas. In addition, there are strong concerns in the farming community about pumping ground water into wetlands, so sensitivity on when water is used and the amount used is necessary. Finally, there is a need to spend pumping funds wisely. Delaying most of the pumping to later in September or October takes advantage of generally declining evapotranspiration rates and saves money and water. Most areas can be pumped to water levels sufficient for hunting within 2 weeks (especially if the vegetation has been managed); however there may not be an adequate depth of water for hunting boats. The money saved by delaying pumping can be applied to pumping later into October to provide waterfowl hunting opportunities for the entire season. In the spring, pumping usually begins in mid-February to provide ponded water for the birds when they arrive. Pumping is stopped when the desired water levels are reached.

The USFWS and NGPC must also decide where to pump. In August staff from both agencies assess wetland water and habitat conditions. This assessment is not conducted earlier because water conditions can change rapidly. Both agencies exchange information on habitat conditions and evaluate wetlands that they feel should be pumped. Part of the evaluation of habitat includes assessing the density and distribution of wetland vegetation. Pumping into wetlands that are choked with dense stands of vegetation will not usually provide the quality of habitat as pumping into an area that has been managed (through grazing, burning, mowing, disking, herbicide application, etc.) to reduce the density of the vegetation and increase moist-soil plants attractive to waterfowl. This information is then used to make decisions about where to pump and allows land managers to estimate the amount of water needed to provide adequate ponding in these wetlands. Based on this information, and considering the amount of dollars available, a list is compiled of wetlands to be pumped.

Another consideration that is taken into account is the fact that wetlands are not always wet. It is beneficial for wetlands to periodically go dry so the agencies do not pump all of the wetlands all of the time. There are two additional reasons that more areas are not pumped. Many existing public areas cannot be pumped because the USFWS or NGPC do not own enough of the wetland and pumping could possibly flood a neighbor's land. There may be opportunities to obtain flooding agreements from neighbors or to pay for neighbors to provide supplemental water for public/private areas. The final reason is that it costs money to drill new wells, acquire pumps, and operate the pumps. But as funds become available, new pumps and wells will be added.

The amount of water pumped in any one year varies greatly depending on wetland conditions. In some years almost no pumping is done. On average, with spring and fall pumping combined, approximately 2,500 acre-feet of water are pumped on public lands. To put this in perspective, this is equivalent to the amount of water used to irrigate crops on about 3 sections of land. Both agencies comply with all Natural Resources District and Nebraska Department of Natural Resources rules regarding wells and groundwater use.

OVERVIEW OF CONSERVATION STRATEGIES TO INCREASE PONDED HABITAT

The remainder of this document outlines a set of strategies to meet the habitat objectives for migrating waterfowl and other wetland dependent birds. These strategies try to balance the biological goals with the social constraints outlined above. Strategies include protection and restoration of sufficient wetland acres, upgrades to supplemental water delivery infrastructure, and the financial investment that will be required for delivering supplemental water in a timely fashion. In the RWB, there are six primary strategies identified to ensure sufficient ponded habitat for wetland-dependent migratory birds during migration. These strategies are:

1. Acquire from willing sellers a minimum of 7,990 acres of public land roundouts from the total of 11,620 acres (RWBJV 2013c) to facilitate restoration and maximize ponding frequency on wetlands that have a public ownership nexus.
2. Enroll an additional 9,250 private wetland acres and 4,335 acres of adjacent upland buffer into voluntary long-term conservation programs.
3. Complete hydrologic restoration to the fullest extent possible on all public wetlands.
4. Work with landowners to voluntarily restore watershed hydrology to public wetlands and those private wetlands enrolled in long-term conservation programs.
5. Install new, and upgrade existing infrastructure to efficiently use supplemental water from high capacity wells or surface water to increase ponded wetland habitat.

Common activities include drilling new high capacity wells, rehabbing existing high capacity wells, upgrading surface water delivery infrastructure, and installing pipelines to maximize efficiency.

6. Develop an endowment fund that will financially support operation of high capacity wells and surface water deliveries to ensure ponding annually on 45% of the wetlands enrolled in long-term conservation programs or under public ownership. Priority will be placed on supplemental water deliveries, but when appropriate dividends from the endowment may be used for other conservation actions (i.e. acquisition of roundout acres, infrastructure upgrades, etc.) that support increased ponding.

1. Strategic Acquisition of Roundouts

There are 94 publicly owned properties in the RWB managed by either NGPC (35 WMAs) or the USFWS (59 WPAs). These properties contain all, or portions, of 172 wetland footprints, or approximately 1.5% of the historic wetland footprints, and contain 19,230 acres (13,413 acres on WPAs and 5,818 acres on WMAs) of hydric soils. This small number of public properties provides approximately half of the foraging resources available to spring migrating waterfowl under average climatic conditions (RWBJV 2013*c*). To maximize available habitat on the existing public lands, acquisition of roundouts from willing sellers has been established as a priority because these tracts, when acquired, complement the existing public land base. When the entire hydric soil footprint is owned, full hydrologic restoration can be completed. In addition to restoration, management efficiency and effectiveness increase (USFWS 2011). For example, some management treatments, like grazing, fire, and/or chemical applications may not be implemented because of a lack of infrastructure or the potential of perceived impacts to adjacent properties. Also, without complete ownership, full hydrologic restoration is often not pursued on wetlands with multiple owners because of either a real or perceived potential for impacts to adjacent landowners. There are 783 tracts classified as public land roundouts (RWBJV 2015b). These parcels contain 10,528acres of hydric soil. The RWBJV accepted 75%, or 7,900 roundout acres, as a realistic target to acquire over the next 20 years.

To help prioritize the most critical roundout tracts, the RWBJV Acquisition Workgroup developed ranking criteria. These criteria were integrated into a GIS model to create a spatially explicit Decision Support Tool (DST-known as the RWBJV Roundout Model [RWBJV 2015a]), which identifies parcels that best fit the ranking criteria. The criteria included: percent wetland in offer, ownership, potential disturbance factors, and land use (RWBJV 2015*b*). The scores from all criteria were summed together for each tract to arrive at an overall enrollment priority score. Of the 783 tracts that were evaluated using the RWBJV Roundout Model, the highest two priority classes contained a total of 277 tracts with 7,952 hydric acres , roughly corresponding to the 75% acquisition target. All acquisitions will be vetted individually, however emphasis will be placed on the highest ranking tracts. The Roundout Model is also used to focus on marketing and outreach efforts, so landowners with priority tracts understand their options and opportunities.

The RWBJV partnership only pursues acquisitions on a willing seller/willing buyer basis and for this reason recognizes that not all roundouts will be available for purchase. The RWBJV is also cognizant of the social perception surrounding public land acquisition and its effect on county real estate taxes, as well as the agency costs associated with ownership, management, and restoration of new acquisitions. For these reasons, the RWBJV Implementation Plan goal for acquisition is 7,900 acres of roundouts (75% of the priority roundout acres) and 4,525 acres of adjacent upland buffer (12,425 acres total).

To achieve the 12,425 acre (wetlands and upland buffer) strategy established as part of the Public Land Acquisition Target, the RWBJV partnership will need to acquire an average of 626 acres per year for the next 20 years. Based on the average 2015 Geographic Area Rate Caps (GARC) developed by the Natural Resources Conservation Service (NRCS), the price of irrigated cropland in the central region was estimated at $4,055/acre. With an average annual acquisition of 626 acres, the yearly cost is estimated at $2,550,295/year. To accomplish the roundout acquisition strategy in the next 15 years will require $38.3 million.

2. Long-term Conservation Program Enrollment

Private wetlands enrolled in long-term conservation programs are treated as a distinct conservation target because these programs are administered through deed restrictions or easements. Both deed restrictions and easements ensure the wetlands and associated uplands will not be drained or cropped, nor will construction of permanent structures on the easement area occur. Generally, the easements promote livestock grazing to ensure economically sustainable management of the site. These conservation tools are typically structured for at least 30 years, and most are perpetual. Multiple non-governmental organizations and several subdivisions of government administer these easements, including Ducks Unlimited (DU), Pheasants Forever, Natural Resources Districts, NRCS, and the USFWS. This diversity of partners ensures that easements can be structured to maximize flexibility and incorporate solutions whereby the wetlands and associated uplands can be integrated into working agricultural operations while maximizing habitat for wetland-dependent migratory birds. As of December 2016, there were 77 properties (6,346 acres of wetlands and uplands) enrolled in long-term conservation programs that protect 3,450 acres of wetlands.

At target, an additional 9,250 acres of wetlands and 4,335 acres of adjacent upland buffer (13,585 total new acres) will be enrolled in long-term conservation programs. The RWBJV Easement Model (RWBJV 2015b) is a spatially explicit DST designed to assist easement enrollment by identifying tracts that, if protected and restored, have a high potential of providing quality habitat for migrating waterfowl and other wetland dependent birds. Criteria used to rank different tracts included current functional wetland area and the percentage of the tract with functioning wetlands, restoration potential, proximity to areas currently under long-term conservation, wetland ownership, wetland density, disturbance factors, upland buffer percentage, restoration complexity, presence of irrigation wells for supplemental water and the presence of electrical transmission lines (RWBJV 2015*a*). The scores from all criteria were summed together for each tract to arrive at an enrollment priority score. Overall, 16,388 tracts were evaluated using the RWBJV Easement Model. Tract scores ranged from 15 to 245, with an average score of 95. Tracts were sorted into four categories based on their score using a natural breaks classification. The highest priority class contained 1,722 tracts (11%) with scores greater than 135. Tracts already enrolled in long-term conservation programs or under public ownership were excluded from analysis in the model.

To achieve the strategy of adding 13,585 acres the RWBJV partners will need to enroll into conservation programs, on average, 680 acres per year over the next 15 years. Assuming average easement plus restoration costs of $4,555/acre (derived from GARC payments averaged from 2010 – 2015 resulting in an average WRE restoration cost of $500/acre), the average cost of annually enrolling and restoring 680 acres would be $3.1 million/year. Approximately $2.76 million of this amount would be used for easement purchases and the remainder for restoration. To achieve the long-term private lands enrollment and restoration objectives within the next 15 years will require $46.5 million in funding.

3. **On-site Hydrologic Restoration**

All RWB wetlands were in private ownership at one time. Pivot irrigation took hold in the RWB in the 1960's and 1970's. To maximize irrigation efficiency pivot irrigation systems must complete full rotations. As a result, marginal wetland acres within tracts were put into production. To maximize production on these acres concentration pits, surface drains, tile drains, and dikes were constructed, along with fill material being placed in the wetlands (McMurtrey et al. 1972). In addition to the negative impacts of the on-site wetland modifications, the uplands surrounding the wetlands are cropped and culturally-accelerated sediment is often deposited in the wetlands due to runoff from intense precipitation events. As a result, when wetlands are purchased by public agencies they often require restoration. Both the USFWS and NGPC have made significant progress in restoring public wetlands to the fullest extent possible and in promoting the natural hydrologic characteristics of each wetland. Efforts have included filling concentration pits, removing surface drains, re-contouring waterways, excavating fill material, and removing culturally-accelerated sediment. Even with the past efforts additional restoration is needed on many of the existing properties. Appendices A and B outline the necessary on-site wetland restoration activities for all public properties.

In addition to restoration of the existing public land base, most roundouts will also require some degree of hydrologic restoration. As part of the RWBJV Implementation Plan, removal of concentration pits located within the hydric soil footprints of public roundout acres was identified as a priority. The potential priority roundout properties contain 140 pits. Consistent with the revised RWBJV Implementation Plan, the strategy is to remove a minimum of 75% of the pits within the roundout tracts, or 105 pits. Full hydrologic restoration of these wetlands will always be pursued.

Since 2010, the RWBJV has had an active public wetland/watershed restoration initiative. As part of this initiative, 13 concentration and irrigation reuse pits had been filled that impacted private wetlands; while 146 of these features were filled that were impacting public wetlands. The average cost to remove a pit was $20,000. With a target of removing approximately 105 concentration pits on roundout acquisitions, the RWBJV will need to leverage $2.1 million or ~$140,000 a year for the next 15 years.

The other major wetland impediment is fill material and/or culturally-accelerated sediment within the hydric soil footprint. This non-hydric soil, or sediment/fill material, stores more water within the sediment's/fill soil profile than does the natural hydric soil profile. As a result, ponded water, and ultimately available wetland habitat, is significantly reduced over these areas. Vegetation monitoring conducted annually from 2010 through 2014 documented that 3,160 acres of hydric soils were growing upland plant communities rather than wetland plant communities. The presence of upland vegetation communities on mapped hydric soils suggest these areas have received significant deposits of culturally-accelerated sediment or fill material. To meet the target in the Implementation Plan, the fill material and culturally-accelerated sediment will be removed from these acres along with 370 acres in hydric soils that have been identified for restoration. Soil surveys will be conducted to identify the distribution and deposition of the sediment and fill material. It is estimated that removal of fill material or culturally-accelerated sediment from these acres will result in an additional 1,500 acres of ponded habitat under average climatic conditions. Many of the wetlands enrolled in long-term conservation programs are restored to the extent possible to meet program requirements. Therefore goals for additional restoration activities have not been developed, that said, if additional restoration is needed, it will be addressed on a site by site basis.

Scrapers and other heavy equipment will be used to remove culturally-accelerated sediment. The average cost to remove six inches of material is currently $2,500/acre. Although some areas may require deeper sediment removal, we estimate the cost to restore the 3,530 acres at $8.8 million, or $588,333 annually over the next 15 years.

4. **Off-site Watershed Restoration**

Prior to adoption of center pivot irrigation systems, crops were irrigated using gravity irrigation. To effectively implement gravity irrigation, a producer used a high capacity groundwater well to deliver water to the uphill end of the field. The water was released through gated pipe and flowed down furrows between the rows where the crops were growing. In 1964 the Nebraska Legislature passed a state statute requiring persons using groundwater for crop irrigation purposes to control irrigation runoff and prevent it from flowing onto adjacent land. Consequently, irrigators constructed reuse pits to capture irrigation runoff. These pits were often placed in natural drainages or at the lowest points in a field, allowing producers to capture runoff. Pumps were used to recirculate the water back to the upper ends of the fields where it could be re-applied.

Irrigation reuse pits were an effective groundwater irrigation conservation practice. A 2010 GIS assessment indicated that approximately 11,000 of these pits had been constructed in the RWB. Based on NRCS construction specifications, the estimated storage capacity of these pits is 56,000 acre feet. This storage volume would be sufficient to pond two times the amount of needed wetland acres to a depth of six inches (preferred foraging depth <12"; Guillemain and Fritz 2002) and would thereby increase available energy for spring migrating waterfowl.

Today, most producers have abandoned gravity irrigation in favor of more efficient center pivot irrigation systems. As a result, many of the concentration/irrigation reuse pits are no longer necessary for irrigation water management. Unfortunately, there is little motivation for producers to remove these pits from their fields. They are an inconvenience to farm around, but the cost to fill them with compacted soil is high. As a result, many abandoned pits continue to capture natural runoff and therefore reduce the total volume of water that historically would have flowed into wetlands. Based on the GIS assessment, concentration/irrigation reuse pits have been identified as one likely cause of low ponding frequency. The 2013 RWBJV Implementation Plan (RWBJV 2013a) identified 874 concentration and/or irrigation reuse pits in the wetlands or watersheds of public RWB wetlands. The pits had an aggregate capacity of 3,263 acre-feet, or approximately 19% of the historic storage capacity (Bishop and Grosse 2012) of wetlands in public ownership.

The RWBJV Watershed Restoration Initiative has utilized a variety of funding sources to fill 146 concentration/reuse pits to restore hydrologic function to public wetlands. Restoration activities have included filling 8 concentration pits within hydric soil footprints along with 138 irrigation reuse pits within in the associated watersheds. As stated above, on-site restoration (within the hydric soil footprint) is focused on removing an additional 105 concentration pits, while watershed restoration is focused on the 75% remaining irrigation reuse pits in the watersheds of publicly owned wetlands. As a result there are 413 additional irrigation reuse pits that remain to be filled to achieve the targets outlined in the RWBJV Implementation Plan.

For private wetlands enrolled in long-term conservation programs there are 385 pits in the watersheds. These pits are estimated to have a storage volume of 1,437 acre feet of water. A strategy was set to remove 75% of these features, which equates to removing 289 irrigation reuse pits. Thirteen of these pits have already been filled leaving 276 more to fill.

Based on past restorations completed through the RWBJV Watershed Initiative, the average cost to fill an irrigation reuse pit is $20,000 (2010-2015). Project components often included removing the concentration pits/ irrigation reuse pits along with measures to improve water conveyance such as replacing road culverts and re-contouring waterways to ensure that runoff reaches the wetland.

With a strategy of removing 413 irrigation reuse pits in the watersheds of publicly owned wetlands, the RWBJV partners will need $8.25 million, or $550,000 annually over the next 15 years to complete these projects in the timeframe outlined in the RWBJV Implementation Plan (15 years remaining). For wetlands enrolled in long-term conservation programs, approximately $5.5 million will be needed or $368,000 annually over the next 15 years for private wetland watershed restoration activities.

5. **Water Delivery Infrastructure**

Since most RWB wetlands were located within irrigated cropland before being owned by public agencies, many have high-capacity irrigation wells. Both the USFWS and NGPC use these high-volume wells to provide supplemental water during fall and spring migration. Between the two agencies there are 143 wells, 75 of which are operational. The RWBJV partners continue to upgrade these wells and drill new wells when necessary. Priority is given to properties where a significant portion of the wetland is under public ownership and has been restored so the wetland can be pumped without negatively impacting adjacent landowners. Appendices A and B outline the infrastructure needs identified by both NGPC and the USFWS to increase efficiency and allow for the addition of supplemental water to public areas. Total estimated costs for each category are also shown.

In the 1930's, the Central Public Power and Irrigation District was established and began construction of the Tri-county Canal project to develop surface water irrigation in Gosper, Phelps, and Kearney counties. As a result, multiple wetlands in the western basins could also receive supplemental water from surface water deliveries from these canals. There are eleven public and private wetlands that encompass 1,750 acres of hydric soils that can be serviced by these canals. Site assessments were completed for these eleven wetlands. For each wetland, the needed upgrades were described and inventoried. These inventories were used to develop a budget and describe the funding necessary to maximize canal water deliveries to the eleven wetlands. A combination of additional pipelines, headwalls, and onsite infrastructure (i.e. replacing road culverts and/or water control structures) were identified at the different sites. Costs varied by practice. For example, a 12-inch plastic irrigation pipe capable of handling 80 pounds of pressure could be installed for $4.88/ft. while a 24-in. pipe costs $21.05/ft. Retrofitting headwalls costs an estimated $9,000, replacing 36-inch road culverts would cost approximately $80/ft., and a 24-inch Agri- Drain water control structure costs roughly $3,500. Infrastructure upgrades for these 11 wetlands would cost approximately $400,000 (Appendices C and D). Costs for additional infrastructure and restoration activities are outlined in Appendices E and F.

6. **Operation and Maintenance Funding**

The NGPC and USFWS use both high-capacity wells and surface water deliveries to supplement additional runoff into their properties. Between the two agencies, there are 75 wells that are operational. NGPC primarily pumps in the fall (85% of total pumping) to maximize hunting opportunities, provide fall migration habitat, and facilitate a higher probability of spring ponding. NGPC pumps 15% of their total in the spring. The USFWS provides most of its supplemental water in the spring (65%) to support bio-energetic needs of migrating waterfowl, Whooping Cranes, and shorebirds (Drahota 2014a). Both NGPC and USFWS budget for supplemental water deliveries. Although there has been variability in budget cycles, over the past ten years NGPC has allocated an average of $30,000, and the USFWS has expended an average of $50,000 annually. Over the last five years the average cost of operating groundwater wells was $39.20 per acre/ft. pumped. Land managers currently assume a 1.5:1 ratio, meaning 1.5 acre feet of supplemental water will result in one ponded acre. This assumption is based on observations made from pumping wetlands that had the greatest potential to quickly pond water (i.e. saturated soil profile and pumping started after the first frost to reduce evaporation and transpiration). Assuming a 1.5:1 ratio, the $80,000 of current pumping and surface water deliveries provide 1,020 acres of additional ponded habitat annually.

Once the roundout acquisition goals have been achieved, there will be 26,800 acres of wetlands under public ownership. The Implementation Plan has a target of having 45% of these acres (12,060 acres) ponded on an annual basis to provide sufficient available habitat on these acres. Based on the RWBJV Annual Habitat Survey (2004-2013) the average number of ponded acres on RWB public lands during peak spring migration was 2,685, with an additional 565 acres ponded on the adjacent roundouts (RWBJV 2013*c*). Current models suggest that 2,450 acres of ponded habitat will be added by implementing watershed restorations, and an additional 1,500 acres will pond water after sediment has been removed and other on-site restorations completed. These combined restoration activities are expected to result in 3,950 acres of additional ponded habitat under average climatic conditions. After roundout acquisition and restoration, public lands in the RWB will provide an estimated 7,200 acres of ponded habitat under average climatic conditions, assuming roundout acquisitions are focused on those tracts that reliably provided the 565 acres of habitat in the past. With current average pumping (1,020 acres), there would be 8,220 acres of ponded habitat in years with average precipitation, still falling short of the target.

To achieve the goal of 12,060 acres of ponded habitat on public lands, the RWBJV would have to address a 3,840 acre deficit under average conditions. To pond water on these additional acres will require that dry wetlands be pumped, and that the pumping window be expanded into the fall. To meet the target, the RWBJV partners would like to have 35% of the deficit acres (1,345) ponded in the fall and the remaining ponded during spring migration (2,495 acres) through supplemental water deliveries. Based on past pumping activities it has been noted that pumping dry wetlands requires more supplemental water, since the soil profile has to become saturated to seal the clay pan before ponding can occur. Fall pumping can also result in transpiration and evaporation losses depending on weather conditions when the pumping occurs. Despite these issues, additional fall pumping will boost public support and improve logistics. Additional fall pumping will increase hunter opportunities and will also set these basins up to pond water from natural runoff in the spring, since the soil profile will likely be saturated. With limited staff, fall pumping will ensure all of the daily maintenance can be completed, which might be difficult if all of the pumping were just occurring in the spring. To address the need for fall pumping and delivery of supplemental water, a 2:1 (supplemental water:ponded area) ratio was used to estimate endowment costs for fall pumping. Based on this ratio, 2,690 acre ft. would need to be pumped in the fall. These fall deliveries would cost $105,450 based on the average cost of operation ($39.20/acre ft.). To provide the additional 2,495 acres of habitat during spring migration approximately 3,745 acre/ft. would need to be pumped assuming the 2:1 (supplemental water:ponded area) ratio set for spring pumping. If Natural Resource Districts implement groundwater pumping allocations, strategies will have to be implemented to stagger wetland pumping so the properties do not come out of compliance with the rolling average pumping allocations (i.e. 27 inches over three years). These supplemental water deliveries would cost $195,600.

Total supplemental water delivery costs for these fall and spring deliveries would be $301,050. NGPC plans to continue with their commitment of $30,000 annually and will increase funding for spring pumping by $5,000, while the USFWS plans to add a $70,000 fixed cost line item in their budget to support pumping objectives and provide adequate spring habitat. As a fixed cost these funds will be more reliable and the $70,000 level is a $20,000 increase over what has been available in the past. It is estimated that an endowment of $5.5 million with a 5% return on investment would be needed to provide an annual dividend of $276,050 necessary to complement the current and committed agency levels to achieve desired ponded conditions on public lands, under average climatic conditions.

At target levels, there will be 12,700 acres of private wetlands enrolled in long-term conservation programs. As part of the RWBJV Implementation Plan, the strategy is to have 45% of these acres (5,715 acres) pond water during spring migration to meet habitat needs of migratory birds. Hydrologic restorations that have occurred on private lands through enrollment in long-term conservation programs have contributed to ponding water approximately 33% of the time between 2004 – 2013. This equates to approximately 4,190 acres of ponded habitat at target levels. The watershed restorations are expected to result in an additional 1,080 acres of ponded habitat. Based on these estimates, there would be 5,270 acres of ponded habitat on private wetlands enrolled in long-term conservation programs. This leaves a deficit of 445 acres of ponded habitat. As with the public lands, the target is to address the deficit with 35% of the acres ponding water in the fall (155 acres) and 65% in the spring (290 acres). For budgeting, the 2:1 ratio was used to estimate the amount of supplemental water necessary to pond water on these acres. Based on this ratio, 890 acre feet of water would need to be pumped. At $39.20 this would cost $35,000. An endowment estimated at $700,000 will be needed to provide an annual dividend that covers these pumping costs.

As outlined above, a $5.5 million dollar endowment will be required for supplemental water deliveries on public lands while a $700,000 endowment will be necessary for supplemental water deliveries on private lands. Building a $6.2 million dollar endowment to facilitate reliable public and private lands wetland pumping will be challenging. Given the current challenges with hydrologic alterations, sedimentation (Daniel et al. 2015, Luo et al. 1997, Smith et al. 2011), invasive species, and climate change (Uden 2012), land managers will likely be faced with declining available habitat most springs that will increase the need to provide supplemental water. It should be noted that land acquisition in the RWB is extremely costly now and will be even more so in the future. Irrigated farm ground in the RWB, on average, costs $7,500/acre with a quarter section of land selling for upwards of $1.2 million. For the cost of five quarter-sections of farmland (800 acres) the RWBJV partners could greatly increase ponding frequency on existing public lands and on private lands enrolled in long-term conservation programs. These supplemental water deliveries could provide as much as 4,285 acres of ponded habitat during fall and spring migration each year which would not be there otherwise. Along with the protection, restoration, and enhancement actions outlined in the RWBJV Implementation Plan, these supplemental water deliveries would support meeting the 45% ponded habitat target on public (12,060 acres) and private (5,715 acres) wetlands enrolled in long-term conservation programs under average climatic conditions.

This endowment will be managed by DU with direct oversight of expenditures by the RWBJV Management Board. The exact investment strategy and disbursement time to the RWBJV from DU will be outlined in a Memorandum of Understanding between DU and the RWBJV. To develop the slate of priorities for endowment expenditures land managers with DU, NGPC, and USFWS will meet in August to discuss habitat conditions and identify those sites where fall supplemental water deliveries could provide the greatest habitat benefits. Once the wetlands have been prioritized based on opportunity, a larger meeting will be held with USFWS, NGPC, DU, Tri-Basin Natural Resources District, Little Blue Natural Resources District, Upper Big Blue Natural Resources District and Nebraska Department of Natural Resources to go over the water delivery plans and maximize communication about the supplemental water delivery plans and opportunities to collaborate for additional water deliveries for habitat and groundwater recharge or in-stream flow benefits.

At full funding there will be $108,500 available for fall supplemental water deliveries with $97,650 for public lands (90% of the available funds) $10,850 for private lands (10% of the available funds). In the spring there will be $201,500 available for supplemental water deliveries with $181,350 for public lands (90% of the available funds) $20,150 for private lands (10% of the available funds).

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Appendix A. Groundwater Infrastructure and Upgrades Necessary for Nebraska Game and Parks Wildlife Management Areas

WMA	County	NRD	Number of Wells w/o Motor	Number of Wells w/ Motor	GPM	Power Unit(s)	Previous 5-10 Years Average Pumping Cost	Estimated Acres OR Acre Feet of Water With Average Pumping	Additional Well(s) Needed (Yes or No)	Other Infrastructure Needs or Upgrades Needed to Maximize Water Delivery Capabilities	Floodage Easement on Neighboring Land Helpful to Maximize Capacity (Yes or No)?	Hydric Soil Acres on Public Area	Number of Footprints	Max Ponding Acres on Public Area (2004-2015)	Min Ponding Acres on Public Area (2004-2015)	Average Ponding Acres on Public Area (2004-2015)	Hydric Soil Acres of the Entire Wetland Footprint	Number of Roundouts	Sum of Hydric Soil Roundout Acres	Max Ponding Acres All Hydric Soil (2004-2015)	Min Ponding Acres All Hydric Soil (2004-2015)	Average Ponding Acres All Hydric Soil (2004-2015)	TOTAL Number of Pits Remaining*	Number of Pits Remaining In the Hydric Soil Footprint*	Number of Pits Remaining in the Watershed*
Ayr Lake WMA	Adams	Little Blue	0	1	unkn	E	new well in 2017 - unkn	n/a	No			139	1	100.9	0.0	27.9	313	6	174	212.9	0.0	54.8	10	2	8
Bluebill WMA	Fillmore	Upper Big Blue	0	1	1000	E	$1,344/yr	49 acre ft	No			39	2	26.6	0.0	12.6	52	4	13	26.9	0.6	13.2	1	1	0
Bluewing WMA	Clay	Little Blue	0	2	1200	2-E	$1,500/yr	14 acre ft	No		Yes	207	2	150.7	0.0	43.4	333	8	125	159.6	0.7	45.2	23	3	20
Bulrush WMA	Clay	Little Blue	0	1	1100	E	$2,000/yr	24 acre ft	No		Yes	141	1	80.3	0.0	29.9	165	3	24	81.1	0.0	30.3	10	1	9
Deep Well WMA	Hamilton	Upper Big Blue	0	1	850	E	$1,800/yr	32 acre ft	No			104	1	43.2	0.0	21.7	199	5	94	46.6	0.9	25.6	4	1	3
Father Hupp WMA	Thayer	Little Blue	0	1	900	E	$1,405/yr	44 acre ft	Yes	needs another well		149	1	88.0	0.7	30.8	457	10	309	175.8	1.8	47.7	9	5	4
Flatsedge WMA	Polk	Upper Big Blue	0	1	Unkn	E	new well in 2016 - unkn	n/a	No	soil regrading		54	1	7.6	0.0	1.6	144	4	90	9.7	0.0	2.0	4	0	4
Gadwall WMA	Hamilton	Upper Big Blue	0	0	n/a	n/a	n/a	n/a	Yes	has a new well planned, year of installation undetermined		87	1	61.6	0.0	13.7	168	7	81	71.8	0.0	19.9	1	1	0
Greenhead WMA	Clay	Little Blue	0	1	1000	E	$1,600/yr	20 acre ft	No			57	1	38.1	0.0	17.7	122	4	65	58.8	1.4	21.6	4	0	4
Greenwing WMA	Clay	Little Blue	0	1	900	P	$1,402/yr	47 acre ft	No			55	1	44.5	0.8	29.1	96	4	41	47.6	0.8	30.3	3	3	0
Hidden Marsh WMA	York	Upper Big Blue	0	1	650	E	new well in 2016 - unkn	n/a	No			39	3	17.4	0.0	5.7	72	6	33	24.2	0.7	9.4	1	1	0
High Basin WMA	Phelps	Tri Basin	0	0	n/a	n/a	n/a	n/a	Yes	needs a well		61	2	57.6	0.0	7.8	106	5	45	82.3	0.2	10.9	8	2	6
Kirkpatrick Basin North WMA	York	Upper Big Blue	0	2	600	1-E, 1-LS-ES	*no data*	*no data*	No			298	3	164.0	0.0	52.2	389	7	91	187.0	0.9	55.7	3	1	2
Kirkpatrick Basin South WMA	York	Upper Big Blue	0	3	1000	2-E, 1-LS-W	$400/yr	33 acre ft	No		Yes	376	1	248.1	0.0	43.8	511	10	134	265.0	0.3	47.2	5	4	1
Kissinger WMA	Clay	Little Blue	0	1	1650	E	$2,600/yr	32 acre ft	No			261	2	168.4	22.4	88.3	277	3	16	173.5	22.8	89.2	3	0	3
Marsh Duck WMA	York	Upper Big Blue	0	1	1000	E	*no data*	50 acres	No		Yes	89	2	46.2	0.5	16.9	211	9	122	80.6	4.4	32.3	5	4	1
Marsh Hawk WMA	Fillmore	Upper Big Blue	0	1	1,100	P	*no data*	50 acre ft	No		Yes	126	1	42.9	0.0	12.7	158	5	32	45.9	1.9	16.5	1	1	0
North Lake Basin WMA	Seward	Upper Big Blue	1	1	800	E	*no data*	*no data*	No		Yes	336	1	139.5	1.0	54.9	1,081	27	744	203.2	2.5	75.4	7	5	2
Northeast Sacramento WMA	Kearney	Tri Basin	0	0	n/a	n/a	n/a	n/a	No			35	1	3.5	0.0	0.6	154	4	118	11.8	0.0	3.6	16	2	14
Pintail WMA	Hamilton	Upper Big Blue	0	1	1600	NG	$2,500/yr	25 acre ft	Yes	needs another well		379	1	187.4	0.0	39.3	462	9	83	189.2	0.1	44.0	12	1	11
Prairie Marsh WMA	Thayer	Little Blue	0	1	650	E	$994/yr	26 acre ft	No			38	1	20.5	0.1	7.4	39	2	1	20.7	0.1	7.4	0	0	0
Redhead WMA	Fillmore	Little Blue	0	2	<50	D, LS-E	new well in 2017 - unkn	n/a	No		Yes	74	1	50.9	0.0	16.9	362	4	288	142.4	0.0	44.0	3	1	2
Renquist WMA	York	Upper Big Blue	0	1	1050	E	$379/yr	35 acres	No			96	1	55.7	0.0	29.4	143	4	47	64.7	0.5	33.1	2	1	1
Sacramento-Wilcox WMA	Phelps	Tri Basin	0	6	800	6-NG	$8,000/yr	130 acre ft	No	pipelines and water control structures, convert NG wells to E		1,093	4	420.0	10.0	89.7	1,094	1	2	420.0	10.0	89.7	51	4	47
Sandpiper WMA	Fillmore	Upper Big Blue	0	1	950	E	$547/yr	24 acre ft	No		Yes	86	3	33.3	15.0	25.0	122	11	37	33.3	15.0	25.0	0	0	0
Shypoke WMA	Seward	Upper Big Blue	0	1	1300	E	$200/yr	6 acre ft	No	additional fill/sediment removal		157	1	74.5	0.0	22.4	1,078	21	921	100.3	0.3	43.9	4	3	1
Smartweed Marsh West WMA	Nuckolls	Little Blue	0	0	n/a	n/a	n/a	n/a	Yes	needs a well		92	2	53.6	0.0	24.2	102	4	10	53.6	0.0	24.2	1	0	1
Smartweed Marsh WMA	Nuckolls	Little Blue	0	1	600	E	$1,500/yr	18 acre ft	No			38	1	23.7	0.0	3.1	94	5	56	35.6	0.0	5.6	0	0	0
Sora WMA	Fillmore	Little Blue	0	1	1150	E	$1,281/yr	37 acre ft	No		Yes	139	1	77.6	0.0	30.3	186	3	47	82.8	0.0	32.7	5	1	4
South Sacramento WMA	Harlan	Lower Republican	0	0	n/a	n/a	n/a	n/a	No			113	2	11.9	0.0	1.4	195	8	82	24.1	0.3	5.1	3	3	0
Southeast Sacramento WMA	Harlan	Lower Republican	0	0	n/a	n/a	n/a	n/a	Yes	needs a well		155	1	78.7	0.0	11.5	457	16	302	201.5	0.6	34.4	21	8	13
Spikerush WMA	York	Upper Big Blue	0	1	1100	E	$300/yr	80 acres	No			177	1	75.1	2.1	24.0	212	5	35	75.1	2.1	24.0	4	0	4
Straightwater WMA	Seward	Upper Big Blue	0	1	600	E	$400/yr	22 acre ft	No		Yes	119	1	55.9	0.2	17.1	150	2	30	56.8	0.2	17.4	3	1	2
West Sacramento WMA	Phelps	Tri Basin	0	1	800	P	$1,500/yr	20 acre ft	No			227	1	81.9	0.0	13.1	315	4	87	98.6	0.0	16.0	12	0	12
Whitefront WMA	Clay	Upper Big Blue	0	2	1000	2-E	$2,200/yr	28 acre ft	No	re-align the north underground pipeline	Yes	181	3	51.7	0.3	12.3	263	15	82	69.7	1.8	15.3	6	5	1
NGPC TOTALS	**35 WMAs**		**1**	**40**					**6 - Yes**		**11 - Yes**	**5,818**	**53**				**10,278**	**245**	**4,461**				**245**	**65**	**180**

Appendix B. Infrastructure Needs on U.S. Fish and Wildlife Service Waterfowl Production Areas

WPA	County	NRD	Number of Wells w/o Motor	Number of Wells w/ Motor	GPM	Power Unit(s)	Previous 5-10 Years Average Pumping Cost	Estimated Acres OR Acre Feet of Water With Average Pumping	Additional Well(s) Needed (Yes or No)	Other Infrastructure Needs or Upgrades Needed to Maximize Water Delivery Capabilities	Floodage Easement on Neighboring Land Helpful to Maximize Capacity (Yes or No)?	Hydric Soil Acres on Public Area	Number of Footprints	Max Ponding Acres on Public Area (2004-2015)	Min Ponding Acres on Public Area (2004-2015)	Average Ponding Acres on Public Area (2004-2015)	Hydric Soil Acres of the Entire Wetland Footprint	Number of Roundouts	Sum of Hydric Soil Roundout Acres	Max Ponding Acres All Hydric Soil (2004-2015)	Min Ponding Acres All Hydric Soil (2004-2015)	Average Ponding Acres All Hydric Soil (2004-2015)	TOTAL Number of Pits Remaining*	Number of Pits Remaining In the Hydric Soil Footprint*	Number of Pits Remaining in the Watershed*
Atlanta WPA	Phelps	Tri Basin	1	1	1200	D	$10,568/yr	229 acre ft	No	add ES motor to northeast well and convert D motor to ES	Yes	411	1	347.0	0.0	54.3	431	3	20	357.7	0.0	55.8	20	2	18
Bluestem WPA	Kearney	Tri Basin	1	0	n/a	n/a	n/a	n/a	No	add ES motor	Yes	73	1	18.5	0.0	2.7	99	6	26	22.5	0.0	3.0	5	0	5
Brauning WPA	Fillmore	Upper Big Blue	3	0	n/a	n/a	n/a	n/a	No	add ES motor if restoration is completed	Yes	127	2	23.2	1.8	5.8	330	15	203	32.7	2.4	9.7	7	7	0
Clark WPA	Kearney	Tri Basin	0	1	1323	ES	$1,470/yr	117 acre ft	No	55 acre excavation, pipe extension east into footprint.	Yes	269	2	104.9	0.0	33.4	303	6	34	105.9	0.2	34.0	1	1	0
Cottonwood WPA	Phelps	Tri Basin	0	1	1162	ES	$1,124/yr	152 acre ft	No	additional sediment removal	Yes	245	1	212.4	20.7	74.1	263	4	18	222.8	20.7	75.2	10	1	9
County Line WPA	Fillmore	Upper Big Blue	0	0	n/a	n/a	n/a	n/a	Yes	need a new well near west parking lot with ES motor	Yes	232	2	80.2	0.0	35.4	287	3	55	91.0	0.5	43.9	17	10	7
Eckhardt WPA	Clay	Little Blue	0	1	1343	ES	$2,202/yr	77 acre ft	No			69	2	60.4	10.6	32.9	118	4	49	60.4	10.6	33.0	1	0	1
Elley WPA	Gosper	Tri Basin	0	0	n/a	n/a	n/a	n/a	Yes	add a new well and motor near northeast parking lot, tree clearing, remove sediment, pack soil	Yes	28	1	1.6	0.0	0.1	54	2	27	1.8	0.0	0.6	2	1	1
Freeman Lakes WPA	Seward	Upper Big Blue	0	0	n/a	n/a	n/a	n/a	No	remove sediment, fill pit	Yes	124	1	69.2	2.1	34.5	787	15	663	257.2	3.9	122.3	17	5	12
Frerichs WPA	Kearney	Tri Basin	0	0	n/a	n/a	n/a	n/a	Yes	add new well with ES motor, private land agreement w/ neighbor	Yes	34	1	13.2	0.0	1.2	117	3	84	52.6	0.0	7.9	4	0	4
Funk WPA	Phelps	Tri Basin	1	3	1500	1-ES, 2-D	$12,441/yr	429 acre ft	No	convert two wells from E motor to ES, excavation on Redhead, WF, Center and Mallard units	Yes	741	18	231.5	46.2	107.0	787	9	46	231.9	46.2	107.1	24	1	23
Gleason WPA	Kearney	Tri Basin	0	2	1300	1-ES, 1-D	$2,186/yr	124 acre ft	No	convert D motor to ES	Yes	287	1	92.2	0.1	31.1	291	4	5	92.5	0.1	31.1	2	0	2
Glenvil WPA	Clay	Little Blue	0	0	n/a	n/a	n/a	n/a	Yes	needs a new well with motor	Yes	90	1	28.2	0.0	8.2	147	7	57	49.3	0.0	11.1	10	1	9
Green Acres WPA	Clay	Little Blue	0	0	n/a	n/a	n/a	n/a	No	excavate 3 acres,	Yes	54	1	36.1	0.0	9.3	121	6	67	62.8	0.2	23.3	1	1	0
Griess WPA	Fillmore	Upper Big Blue	0	0	n/a	n/a	n/a	n/a	No	remove sediment from east side	Yes	18	1	12.8	0.0	6.5	78	9	60	29.9	0.0	8.6	1	1	0
Hansen WPA	Clay	Little Blue	0	2	1050	1-ES, 1-D	$10,611/yr	320 acre ft	No	convert south D motor to ES, dike rehab needed on east	Yes	399	3	194.4	21.6	92.8	508	8	109	201.2	27.9	99.5	9	4	5
Harms WPA	Clay	Little Blue	0	0	n/a	n/a	n/a	n/a	Yes	add new well with ES motor, sediment removal	Yes	34	1	17.3	0.0	2.9	45	1	11	17.6	0.0	3.1	1	1	0
Harvard WPA	Clay	Upper Big Blue	1	3	1350	1-ES, 2-E	$8,260/yr	413 acre ft	No	southwest well collapsed, new column and motor for north well, convert two motors from E to ES	Yes	897	2	499.7	8.3	240.4	969	3	72	515.0	8.7	243.8	20	2	18
Heron WPA	York	Upper Big Blue	2	0	n/a	n/a	n/a	n/a	No	add an ES motor to well on main basin	Yes	222	4	94.0	0.7	36.9	821	18	599	138.8	2.7	52.5	5	5	0
Hultine WPA	Clay	Upper Big Blue	1	0	n/a	n/a	n/a	122 acre ft	No	add ES motor to well, convert NG motor to ES	Yes	549	4	420.7	13.2	114.0	704	11	157	439.1	13.9	118.4	8	2	6
Jensen WPA	Kearney	Tri Basin	0	1	1250	D	$5,231/yr	119 acre ft	No	convert D motor to ES	Yes	269	2	95.5	0.0	16.1	300	7	32	96.0	0.3	16.5	4	1	3
Johnson WPA	Phelps	Tri Basin	2	1	1000	ES	$1,564/yr	81 acre ft	No	add ES motor to east well, excavation on east and south, pipe needs extended on west	Yes	164	4	72.6	34.1	56.9	164	0	0	72.6	34.1	56.9	4	1	3
Jones WPA	Phelps	Tri Basin	1	0	1900	D	$1,866/yr	70 acre ft	No	needs an ES motor	Yes	143	1	48.9	0.0	8.6	202	7	59	48.9	0.0	8.7	1	0	1
Kenesaw WPA	Adams	Little Blue	1	0	n/a	n/a	n/a	n/a	Yes	add ES motor to existing well, add another new well, flap gate on culvert, sediment excavation	Yes	154	1	113.3	4.5	23.9	157	2	3	114.9	4.5	24.2	10	0	10
Killdeer WPA	Kearney	Tri Basin	0	0	n/a	n/a	n/a	n/a	No	fill pit on WPA and excavate sediment	Yes	37	1	10.8	0.0	1.2	134	4	97	18.7	0.2	3.4	7	4	3
Krause WPA	Fillmore	Upper Big Blue	1	2	1100	2-E	$3,685/yr	134 acre ft	No	convert two E motors to ES	Yes	296	2	36.1	0.3	9.8	349	5	52	47.0	0.8	13.5	8	7	1
Lange WPA	Clay	Upper Big Blue	0	0	n/a	n/a	n/a	n/a	Yes	fill pit, remove sediment, add well near northeast parking lot with ES motor	Yes	78	2	36.1	0.0	6.6	127	8	49	41.8	0.9	8.4	3	3	0
Lindau WPA	Kearney	Tri Basin	0	1	1236	D	$3,725/yr	82 acre ft	No	restoration work	Yes	128	1	46.4	0.0	20.5	142	9	14	46.7	0.1	20.8	1	1	0
Linder WPA	Phelps	Tri Basin	0	0	n/a	n/a	n/a	n/a	Yes	add new well with ES motor near southwest parking lot	Yes	96	1	81.7	0.0	15.1	108	1	12	87.6	0.0	15.6	2	1	1
Macon Lakes WPA	Franklin	Lower Republican	3	0	n/a	n/a	n/a	n/a	Yes	add ES motors to 2 existing wells, add a new well, excavation, buried pipeline	Yes	753	2	9.1	0.0	1.9	1,398	24	644	54.9	0.0	12.6	35	8	27
Mallard Haven WPA	Fillmore	Upper Big Blue	1	2	1000	1-ES, 1-E	$7,945/yr	380 acre ft	No	convert E motor to ES, add ES motor to north well	Yes	913	1	274.6	29.8	91.5	1,180	18	267	346.0	42.9	133.8	11	3	8
Massie WPA	Clay	Little Blue	0	2	1500	1-ES, 1-D	$9,773/yr	218 acre ft	No	convert D motor to ES	Yes	527	5	272.8	5.6	91.1	601	15	74	275.6	9.8	94.1	8	1	7
McMurtrey WPA	Clay	Little Blue	0	2	1500	2-E	$4,054/yr	179 acre ft	No	convert two motors to ES	Yes	563	1	176.4	0.0	59.1	591	1	28	177.9	0.6	60.4	8	1	7
Meadowlark WPA	Clay	Little Blue	0	0	n/a	n/a	n/a	n/a	Yes	new well with ES motor, pipeline to supplement both footprints	Yes	29	3	9.8	0.0	1.0	39	5	10	9.8	0.0	1.0	0	0	0
Millers Pond WPA	Fillmore	Little Blue	0	0	n/a	n/a	n/a	n/a	Yes	needs a well	Yes	118	1	46.5	0.0	13.6	339	9	221	63.0	0.5	16.8	5	3	2
Moger WPA	Clay	Little Blue	0	1	1900	D	$3,176/yr	62 acre ft	No	22 acre excavation, plug outlet on north wetland, convert D motor to ES	Yes	100	2	73.7	8.5	43.2	137	6	37	74.5	9.0	45.4	1	1	0
Morphy WPA	Fillmore	Upper Big Blue	1	0	Unkn	E	n/a	n/a	Yes	remove middle dike, replace collapsed well column, convert E motor to ES, new well with ES motor	Yes	83	1	49.5	0.0	11.4	96	2	13	50.4	0.0	11.5	0	0	0
Nelson WPA	Hamilton	Upper Big Blue	0	1	Unkn	E	n/a	n/a	No	cannot restore until more land is purchased, convert E motor to ES	Yes	136	1	31.7	0.4	3.6	328	6	192	34.3	1.7	5.8	19	2	17
Peterson WPA	Gosper	Tri Basin	0	2	1000	D	$23,798/yr	211 acre ft	Yes	add new well with motor for south wetland if restored	Yes	577	7	332.9	0.0	33.4	626	9	50	334.6	0.0	34.0	46	3	43
Prairie Dog WPA	Kearney	Tri Basin	0	2	950	D	$4,127/yr	130 acre ft	No	convert two D motors to ES, excavation on 50 acres	Yes	546	1	196.4	0.0	38.5	585	6	38	203.7	0.0	39.6	27	1	26
Quadhamer WPA	Franklin	Lower Republican	0	1	750	D	$9,248/yr	279 acre ft	Yes	add new well and ES motor near west parking lot		326	2	71.8	0.0	14.3	332	5	6	72.0	0.0	14.3	7	0	7
Rauscher WPA	Fillmore	Upper Big Blue	1	0	n/a	n/a	n/a	n/a	No	add ES motor to existing well, excavate sediment	Yes	146	3	38.4	0.0	18.0	307	11	160	40.6	0.0	19.4	1	1	0
Real WPA	Fillmore	Upper Big Blue	0	0	n/a	n/a	n/a	n/a	Yes	add new well with ES motor	Yes	116	1	64.7	0.0	29.5	228	9	112	68.0	1.8	31.9	3	2	1
Ritterbush WPA	Franklin	Lower Republican	0	0	n/a	n/a	n/a	n/a	Yes	add new well with ES motor near northwest parking lot	Yes	49	1	12.4	0.0	1.4	198	9	149	32.5	0.0	8.1	13	6	7
Rolland WPA	Fillmore	Upper Big Blue	0	0	n/a	n/a	n/a	n/a	Yes	new well with motor	Yes	58	1	41.2	0.0	9.0	97	2	39	69.2	0.9	17.8	1	0	1
Schuck WPA	Clay	Little Blue	1	0	n/a	n/a	n/a	n/a	No	add ES motor to well if in good condition	Yes	48	1	7.0	0.6	3.5	79	6	31	24.2	0.9	8.5	1	0	1
Sinninger WPA	York	Upper Big Blue	0	0	n/a	n/a	n/a	n/a	No	excavate southeast wetland and temporary, remove trees	Yes	43	3	13.8	0.0	4.4	210	10	167	81.8	0.8	37.2	0	0	0
Smith WPA	Clay	Little Blue	0	1	1500	ES	$1,848/yr	231 acre ft	No	sediment removal on 15 acres		233	3	191.5	2.8	97.9	287	7	54	194.9	5.2	108.7	2	1	1
Spoonbill Flats	Franklin	Lower Republican	0	1	1000	D	$3,091/yr	74 acre ft	No	need buried pipeline		75	2	2.4	0.0	1.0	110	5	35	2.9	0.0	1.4	7	4	3
Springer WPA	Hamilton	Upper Big Blue	3	1	1000	E	$384/yr	45 acre ft	No	convert E motor to ES	Yes	246	1	80.6	0.0	20.2	305	7	59	92.5	0.0	22.3	16	2	14
Tamora Basin WPA	Seward	Upper Big Blue	3	0	n/a	n/a	n/a	n/a	No	major restoration needed to add 46 acres, add 2 ES motors to pumps north and south of road	Yes	197	2	96.2	0.4	35.9	734	23	537	108.4	0.4	41.9	4	1	3
Theesen WPA	Clay	Little Blue	0	0	n/a	n/a	n/a	n/a	No	excavate sediment from 13 acres	Yes	44	1	38.6	0.0	3.6	234	5	191	131.8	2.1	27.7	10	6	4
Troester Basin WPA	Hamilton	Upper Big Blue	2	0	n/a	n/a	n/a	n/a	No	add ES to west well, excavate sediment from 67 acres	Yes	157	1	105.2	0.0	13.2	204	4	47	128.9	0.0	15.9	0	0	0
Verona WPA	Clay	Upper Big Blue	0	0	n/a	n/a	n/a	n/a	Yes	new well with motor but groundwater is limiting for this area, some sediment excavation	Yes	36	1	20.5	0.0	4.2	39	2	3	21.9	0.0	4.7	0	0	0
Victor Lakes WPA	Gosper	Tri Basin	0	0	n/a	n/a	n/a	n/a	Yes	add new well with ES motor northwest corner south section	Yes	188	2	7.7	0.0	1.4	217	12	29	8.4	0.0	1.6	15	0	15
Waco Basin WPA	York	Upper Big Blue	1	0	n/a	n/a	n/a	n/a	No	add ES motor to existing well, private land pit fill	Yes	151	1	80.7	0.0	21.5	265	4	113	95.5	0.3	24.9	2	2	0
Weseman WPA	Adams	Little Blue	0	0	n/a	n/a	n/a	n/a	Yes	needs well, but area is next to town, low priority WPA	Yes	81	1	25.0	0.0	3.6	155	4	74	30.4	0.8	7.5	1	1	0
Wilkins WPA	Fillmore	Upper Big Blue	0	1	Unkn	NG	n/a	n/a	No	convert NG motor to ES motor, sediment excavation on 176 acres	Yes	478	1	174.6	0.2	46.0	706	12	228	184.9	1.1	49.0	9	7	2
Youngson WPA	Kearney	Tri Basin	0	1	1200	D	$3,040/yr	77 acre ft	No	convert D motor to ES, remove dike, purchase roundout on west end	Yes	128	1	47.0	0.0	7.9	147	5	19	47.2	0.1	8.2	4	4	0
USFWS TOTALS	59 WPAs		31	37					20 -Yes		56 - Yes	13,413	119				19,717	423	6,307				461	123	338

Appendix C. Infrastructure Upgrades to Public Wetlands to Improve Surface Water Deliveries

Public Wetlands		
Site Description	**Infrastructure Needs**	**Estimated Cost**
Cottonwood WPA	Retrofit headwalls	$9,000
Funk WPA	Increase pipeline diameter at multiple sites, retrofit headwalls, replace road culverts, retrofit water control structures	$194,965
Johnson WPA	New pipeline to WPA	$80,675
Linder WPA	Increase pipeline diameter	$55,770
Victor Lakes WPA	Increase pipeline diameter	$43,765

Appendix D. Infrastructure Upgrades to Private Wetlands to Improve Surface Water Deliveries

Private Wetlands		
Site Description	**Infrastructure Needs**	**Estimated Cost**
Ducks Unlimited Anderson Tract	Water control structure to take water from Platte River Recovery and Implementation Program Wetland	$3,500
Cottonwood Ranch Wetland	Retrofit headwalls, increase pipeline, replace road culvert, and replace water control structure	$26,335
Nebraska Public Power District Wetland	New 18 inch pipeline to wetland	$40,335
Mosaic/Gustafson Wetland	Retrofit headwalls and increase pipeline diameter	$16,835
Platte River Recovery and Implementation Program	Water control structure to take water from Nebraska Public Power District Wetland	$3,500
Sandy Wetland Reserve Program Wetland	Retrofit headwalls and increase pipeline diameter	$16,835

Appendix E Infrastructure Needs to Increase Efficiency and Allow for the Addition of Supplemental Water on Public Areas

INFRASTRUCTURE NEEDS	AVERAGE COST/UNIT
New groundwater wells and motor (27 areas)	Average cost - $60,000/well
Conversion of existing well motors to a more efficient energy source (24 areas)	Conversion to 3-phase electric, if a new line needs to be installed, averages $15,000/quarter mile
Installation of well motor on existing wells currently with pumping capacity (17 areas)	Average cost - $12,000/electric motor
Extension of, or addition of a buried pipeline, riser, and rock (8 areas)	$11.09/linear foot

Appendix F. Hydrology Improvement Activities and Estimated Costs

RESTORATION ACTIVITY	ESTIMATED COST
Filling concentration and reuse pits	$20,000/pit fill on average
Removing surface drains	Variable depending on material needed $2.50/cubic yard
Re-contouring waterways	Variable depending on material needed $2.50/cubic yard
Excavate fill material and/or culturally accelerated sediment	Variable but current estimates are $2.50/cubic yard to excavate and spoil material
Low level berms	Variable depending on material needed $2.50/cubic yard